RANDOLPH COUNTY SOIL AND WATER CONSERVATION DISTRICT

UPPER MISSISSINEWA RIVER WATERSHED DIAGNOSTIC STUDY

ENGINEERING COMPANY
WATER & ENVIRONMENT

UPPER MISSISSINEWA RIVER WATERSHED DIAGNOSTIC STUDY

Prepared for

Randolph County Soil and Water Conservation District

Ву

HARZA

Engineering Company

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EXECUTIVE SUMMARY

Randolph County Soil and Water Conservation District (SWCD) of Winchester, Indiana was awarded a grant from the Lake and River Enhancement (LARE) Program of the Indiana Department of Natural Resources (IDNR) to prepare a diagnostic study of nonpoint source pollution in the upper Mississinewa River watershed. Following a competitive procurement process, the SWCD retained Harza Engineering Company for this assignment. The overall objectives of the diagnostic study were to identify sources of pollution in the upper Mississinewa River watershed study area, and, to recommend land management projects, institutional reforms, and potential financing for pollution mitigation.

The upper Mississinewa River watershed is located in Randolph and Jay Counties, Indiana, as well as in Darke County, Ohio. Exhibit 1 shows the 51,207-acre area. For diagnosis, we divided the study area into nine subwatersheds (Exhibit 2), ranging in area from about 1,900 acres to 10,830 acres. We collected historical data on the watershed, including water quality and agricultural practices. There is some evidence of improving water quality conditions in the Mississinewa River, demonstrated by declines in BOD (biochemical oxygen demand) and ammonia nitrogen concentrations. Similarly, there are data demonstrating dramatic adoption of conservation tillage systems in the watershed between 1989 and 1999. We are unable, however, to link the improvements in water quality with the spread of conservation tillage. Improvements in point source controls in Union City, on the Little Mississinewa River, a tributary to the study area, may be responsible for the lower BOD and ammonia nitrogen concentrations.

Physical, biological and chemical data were collected in six of the nine subwatersheds to assess their ecological integrity. We measured very high dissolved oxygen (DO) concentrations in all six streams. We attribute this to the proliferation of filamentous algae on the sand and gravel substrates of the streams. DO concentrations were as high as 274% of saturation. We believe that these streams are subject to very high diural DO fluctuations that can be a stressor for aquatic animals. We attribute these fluctuations to high nutrient concentrations in subwatershed streams.

Key indicators of stream integrity are coliform bacteria, nutrient concentrations, turbidity, the QHEI scores and FBI scores. The QHEI, or Qualitative Habitat Evaluation Index, was developed by Ohio EPA and is a multi-metric index for stream habitat quality (OEPA 1989). The highest QHEI scores reflect good stream habitat. The FBI, or Family Biotic Index, is derived from the US EPA's Rapid Bioassessment Protocol II. FBI was selected

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as the key benthic indicator as it incorporates both diversity and pollution tolerance. The highest FBI scores indicate a healthy macroinvertebrate community. These data for the six streams sampled are tabulated below. Harshman Creek is rated least impacted due to its low nutrient concentrations, low FBI score, moderate turbidity and relatively good QHEI habitat score. Goshen Creek also has a relatively low FBI, but showed high turbidity and inorganic nitrogen concentrations. Jordon, Miller, and Mud Creeks are deemed most impacted by nonpoint source pollution.

SUMMARY OF TRIBUTARY HEALTH INDICATORS

Subwatershed	E. coli	Kjeldahl	NO ₃ +NO ₂	Total P	Turbidity	QHEI	- Tona
Subwatersned	(cfu/100mL)	N (mg/L)	(mg/L)	(mg/L)	(NTU)	Score	FBI
Mud Creek	70 - 7,400	2.1	9.4	0.09	1.9	66.5	5.641
Clear Creek	20 – 810	2.3	7.8	0.08	1.5	74.0	4.648
Miller Creek	10 – 840	2.2	5.9	0.15	1.2	55.5	5.625
Harshman Ck	50 - 720	1.9	3.6	0.06	1.9	68.0	3.744
Jordon Creek	10 – 1,320	4.5	16.0	0.05	3.1	60.5	6.463
Goshen Creek	30 – 340	1.7	9.9	0.05	4.3	67.5	4.013

Additionally, models were developed of all nine subwatersheds to estimate pollution loadings. There are no point source loadings in any of the nine subwatersheds. Mean annual nonpoint source pollutant loadings were estimated using the most reliable information available. Mitchell Ditch subwatershed has the highest mean areal loadings, estimated to be 0.43 tons of sediment and 0.57 kg of phosphorus (P) per acre each year.

ANNUAL SEDIMENT YIELD FOR STUDY AREA SUBWATERSHEDS

Subwatershed	Load (t/yr)	Area (ac)	Areal Sediment Loading (t/ac/y)
Clear Creek (N)	603	1,871	0.32
Clear Creek	3,380	10,830	0.31
Goshen Creek	1,864	5,172	0.36
Harshman Creek	3,086	8,657	0.36
Jordon Creek	1,770	5,624	0.31
Mitchell Ditch	1,477	3,404	0.43
Miller Creek (N)	1,581	4,515	0.35
Miller Creek	2,363	6,496	0.36
Mud Creek	1,773	4,638	0.38
Total	17,897	51,207	

ANNUAL PHOSPHORUS LOADING

Subwatershed	Annual P Load (kg)	Area (ac)	Areal P Loading (kg/ac/y)
Clear Creek (N)	796	1,870	0.43
Clear Creek	4,462	10,828	0.41
Goshen Creek	2,461	5,173	0.48
Harshman Creek	4,073	8,657	0.47
Jordon Creek	2,336	5,624	0.42
Mitchell Ditch	1,949	3,403	0.57
Miller Creek (N)	2,087	4,514	0.46
Miller Creek	3,120	6,495	0.48
Mud Creek	2,340	4,638	0.50
Total	23,624	51,202	

Based upon these data, we sorted the subwatersheds into three groups reflecting their relative need for nonpoint source pollution controls. Mitchell Ditch, Mud Creek and Miller Creek are most stressed and have the greatest areal loadings of sediment and phosphorus. The upper Mississinewa River would benefit from investments in these three subwatersheds.

SUBWATERSHED PRIORITIES FOR NONPOINT SOURCE CONTROL INVESTMENT

Priority	Subwatersheds
	Mitchell Ditch
High	Mud Creek
	Miller Creek
	Jordon Creek
Moderate	Goshen Creek
	Miller Creek N
	Clear Creek
Low	Clear Creek N
	Harshman Creek

Best management practices, or BMPs, are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. For the lands in the study area where corn and soybean production is the dominant use, some of the most effective BMPs include conservation tillage, conservation buffers and nutrient management. In 1999, conservation tillage systems were being utilized on about half of the cropland in Randolph County and nearly two-thirds of cropland in Jay County. Extension agents in these counties are to be commended for their progress and encouraged to continue to educate landowners about the benefits of conservation tillage.

However, we recommend that the SWCD increase its emphasis on nutrient management planning in the watershed. We have documented high stream nutrient concentrations, and these are the probable cause of supersaturation and large diurnal fluctuations of DO.

Constructed wetlands can also be a very effective part of a BMP system. Given the high nutrient concentrations in the study area streams, wetland construction should be considered in high priority subwatersheds: Miller Creek, Mitchell Ditch and Mud Creek. We recommend that the SWCD seek the involvement of local landowners in these three drainages. We recommend their involvement initially be as advisors to a LARE-sponsored engineering feasibility study for constructed wetland in Miller Creek, Mitchell Ditch and Mud Creek subwatersheds. As their interest and understanding of wetland systems and their benefits increases, one or more could possibly serve as co-sponsor for construction of the wetland.

This report also contains an appendix dedicated to the discussion of potential institutional initiatives to maintain and improve the health of the upper Mississinewa River watershed (Appendix A). Watersheds demand attention from a wide variety of stakeholders. There are two principal recommendations for institutional initiatives:

- 1. Formation of a stakeholder group to generate specific implementation recommendations for furthering nutrient management in the study area in general, and constructed treatment wetlands in three priority subwatersheds in particular.
- 2. A conscious planning process, with education as a priority, will provide incentives for stakeholders to be involved. The SWCD and watershed action groups have to take authority and seek resources to identify, develop and carry out needed educational activities, directed primarily toward the land user.

UPPER MISSISSINEWA RIVER WATERSHED DIAGNOSTIC STUDY

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FOREWORD

Authorization

This diagnostic study of the upper Mississinewa River watershed is authorized by a contract between the Randolph County Soil and Water Conservation District (SWCD), of Winchester, Indiana, and Harza Engineering Company, Inc. dated December 3, 1999.

Scope

The scope of the diagnostic study included collection and analysis of secondary and primary data. Principal activities are summarized below.

- 1. Summarize Historical Information. Discussion of historical data on land use, soils, geology, water use and quality, recreation, wildlife, stakeholder and population data.
- Map Current Watershed Conditions, including soils, highly erodible land, wetlands, significant natural areas, threatened or endangered species, critical habitat, land use/land cover, NPDES discharge locations, and other watershed information.
- 3. Evaluate Water Quality, Biology and Habitat. Water quality, Rapid Bioassessment Protocol II, and Qualitative Habitat Evaluation Index data were collected in six tributary sites.
- 4. Watershed Nonpoint Source Pollution. Sediment and nutrient loading for tributary watersheds were estimated.
- 5. Watershed Plan, intended to identify and rank tributary watersheds for land treatment and other projects to mitigate nonpoint source pollution.
- 6. Recommend Institutional Initiatives

Acknowledgments

Financing for this study was provided by the State of Indiana's LARE Program, administered by the Division of Soil Conservation, IDNR and by the SWCD.

Principal participants include Rachael Wilson of the SWCD and Gwen White of the IDNR. The Harza study team included Edward Belmonte, Chris Barden, Beth Padera and Joyce Coffee. David Pott was Harza's project manager.



1.0 INTRODUCTION

This chapter of the diagnostic report describes the study objectives, provides general information and details historical data for the study area.

1.1 OBJECTIVES

The overall objectives of this diagnostic study are to identify sources of pollution in the upper Mississinewa River watershed study area, and, to recommend land management projects, institutional reforms, and potential financing for pollution mitigation.

1.2 LOCATION

The upper Mississinewa River watershed is located in Randolph and Jay Counties, Indiana, as well as in Darke County, Ohio. The study area (Exhibit 1) includes the subwatersheds of Mitchell Ditch, Jordon Creek, Harshman Creek, Mud Creek, Miller Creek, Clear Creek and Goshen Creek. The Little Mississinewa River subwatershed and the Ridgeville subwatershed in Randolph County, Indiana are not included in the study area, nor is the portion of the watershed located in Darke County, Ohio. The Little Mississinewa River watershed has significant contamination from industrial sources and contains a Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) site. CERCLA sites are more commonly known as Superfund sites. The two CERCLA sites west of Union City include A O Smith Electric Motor Company and Sheller-Globe Corporation. Neither of these sites is listed on the National Priorities List.

1.3 WATERSHED SIZE AND TOPOGRAPHY

The entire upper Mississinewa River watershed is approximately 55,600 acres, of which 51,207 acres are included in this study. We have divided the study area into nine subwatersheds (Exhibit 2, Table 1).

UPPER MISSISSINEWA RIVER
SUBWATERSHED AREAS

Table 1

Subwatershed	Area (acres)		
Clear Creek (N)	1,871		
Clear Creek	10,830		
Goshen Creek	5,172		
Harshman Creek	8,657		
Jordon Creek	5,624		
Mitchell Ditch	3,404		
Miller Creek (N)	4,515		
Miller Creek	6,496		
Mud Creek	4,638		
Total	51,207		

Land elevation in the study area ranges from 948 feet to 1,107 feet above sea level (Exhibit 3). The highest elevations occur at the extreme southern and northeastern edge of the study area, and the lowest elevations are along the Mississinewa River at the western edge of the study area.

1.4 LEGAL DRAINS

The Indiana statute at IC 36-9-27 contains the County Drainage Code. This law authorizes county drainage boards to regulate certain drains. The intent of this law is to increase the hydraulic efficiency of waterways and control upstream ponding and flooding. The county surveyor is the technical authority on the construction, reconstruction, and maintenance of all regulated drains or proposed regulated drains in the county. The County Drainage Code requires the county surveyor to classify regulated drains in the county as:

- 1. Drains in need of reconstruction;
- 2. Drains in need of periodic maintenance; or
- 3. Drains that should be vacated.

The county drainage boards across the state fund reconstruction and maintenance of regulated drains. Among the board's duties, as defined in the statute, is the reconstruction of regulated drains that do not properly function and may require erosion control or grade stabilization structures. This is an avenue for implementing watershed management projects that may be underutilized in the state.

Legal drain maps were provided to Harza by the County Surveyor's Offices of Jay and Randolph Counties (Exhibit 4). Watershed management projects affecting drainage in these channels will require the approval of the County Drainage Board. Not all legal drains are represented on the exhibit, only the legal drains within the study area that match the Reach File 3 (BASINS Version 2.0 1998) stream data are shown.

The upper Mississinewa River is classified by the Indiana Natural Resources Commission as a navigable water throughout its length in Randolph County.

1.5 CLIMATE

While Indiana has warm summers and cold winters, temperatures fluctuates both daily and seasonally as surges of polar air move southward or tropical air masses move northward. Temperature fluctuations are more common in winter than in summer. Severe storms and tornadoes are more frequent in the spring months. The upper Mississinewa River watershed experiences some of the moderating effect of Lake Michigan on Indiana's climate, including lake-effect precipitation during the winter months. Temperature and precipitation data for Randolph and Jay Counties are presented below in Tables 2 and 3.

Table 2

JAY COUNTY CLIMATE DATA
(Source: Midwest Climate Center)

	Maximum	Minimum	Mean	Mean
Month	Temperature	Temperature	Temperature	Precipitation
	(F°)	(F°)	(F°)	(in)
January	31.8	14.4	23.1	1.91
February	35.2	16.4	25.8	1.95
March	47.2	27.1	37.2	3.02
April	60.1	37.2	48.7	3.70
May	70.9	48.0	59.5	3.72
June	80.3	57.7	69.0	3.84
July	83.9	61.3	72.6	4.00
August	81.8	58.9	70.3	3.65
September	76	51.5	63.8	2.96
October	63.8	40.2	52.0	2.51
November	50.2	31.9	41.1	2.93
December	36.9	20.8	28.9	2.71
Annual	59.8	38.8	49.3	36.90

RANDOLPH COUNTY CLIMATE DATA
(Source: Midwest Climate Center)

Table 3

Month	Maximum Temperature	Minimum Temperature	Mean Temperature	Mean Precipitation
	(F°)	(F°)	(F °)	(in)
January	31.5	14.2	22.9	1.77
February	35.1	16.2	25.7	1.72
March	47.1	27.3	37.2	3.05
April	59.7	37.7	48.7	3.57
May	71.0	48.3	59.7	3.80
June	80.3	57.7	69.0	4.11

Table 3

RANDOLPH COUNTY CLIMATE DATA
(Source: Midwest Climate Center)

	Maximum	Minimum	Mean	Mean
Month	Temperature	Temperature	Temperature	Precipitation
	(F°)	(F °)	(F°)	(in)
July	83.9	61.5	72.7	3.77
August	81.9	58.5	70.2	3.56
September	76.1	51.8	63.9	3.08
October	64.0	39.8	52.0	2.53
November	50.2	31.8	41.0	2.96
December	37.0	20.7	28.9	2.67
Annual	59.8	38.8	49.3	36.59

1.6 GEOLOGY AND SOILS

Randolph County has seven physiographic subdivisions: bottom land, lake plains, the Knightstown end moraine, the Mississinewa end moraine, outwash plains, the Union City end moraine and till plains. The bottom land is characterized by nearly level soils along the rivers. Many irregularly shaped areas of muck are in deep depressions and potholes.

The Knightstown end moraine is characterized by gently sloping ridgetops and moderately sloping to steep side slopes. It is dissected by numerous streams and drainageways. In general, the steeper side slopes and narrower ridgetops are near the main streams. Large boulders are on the surface and in the subsoil. The Mississinewa and Union City end moraines extend throughout much of the northern and central parts of the county. They are characterized by many abrupt changes in slope, surface texture and land use. Slopes range from nearly level to steeply sloping within short distances. Many irregularly shaped areas of muck are in deep depressions and potholes. The side slopes are commonly eroded. The sloping soils are well drained. In some small areas on sides slopes and in some small drainageways, however, tile drainage is needed. Many natural drainageways are in the depressions and potholes.

The outwash plains also occur along the Mississinewa River and other streams. Small, isolated areas of terraces are along the stream valleys. The outwash plain along the

Mississinewa River is the largest of the plains. It is 0.5 mile to 1.5 miles wide in most areas. Most of the soils are well drained.

The till plains are nearly level in most areas. Areas along the major stream valleys, however, are gently sloping to moderately steep. Most of the till plains are 980 to 1,200 feet above sea level. Most of the creeks and rivers are 50 to 260 feet lower than the plains. Occasionally plains are at different elevations, separated by short slopes (SCS 1987).

Jay County is characterized by nearly level areas between three concentric moraines. Breaks to drainage ways are not steep or very long. In the areas of the moraines, the relief is greater and slopes generally are long and are gently sloping and moderately sloping (SCS 1986).

The major soil associations which occur in Randolph and Jay counties are described below. Exhibit 5 shows the locations of these soil associations within the watershed.

Glynwood-Pewamo-Morley association (Glynwood): Nearly level to moderately sloping, deep, moderately well drained, very poorly drained, and well drained, medium textured and moderately fine textured soils formed in glacial till; on uplands.

Eel-Sloan-Fox association (Sawmill): Nearly level to moderately sloping, moderately well drained, very poorly drained, and well drained, medium textured soils that are deep or are moderately deep over sand and gravel; formed in alluvium and outwash on flood plains and stream terraces.

Blount-Pewamo association (Blount): Nearly level, deep, somewhat poorly drained and very poorly drained, medium textured and moderately fine textured soils formed in glacial till; on uplands.

Fincastle-Treaty-Crosby association (Fincastle): Nearly level, deep, somewhat poorly drained and very poorly drained, medium textured soils formed in loess and in the underlying glacial till; on uplands.

Miami series (Miamian): Deep, well drained soils on till plains. These soils formed in loess and in the underlying loamy till over loamy gravelly outwash (SCS 1987).

1.7 AGRICULTURAL ECONOMY

Agricultural trends that are apparent within Randolph and Jay counties are quite similar for both counties during the ten-year period from 1987 to 1997. The number of individual farms and the amount of land in acres had decreased, where as the average size of each farm has increased. The total harvested cropland by farms decreased by 27.6% and 20.0% for Randolph and Jay counties respectively. The total harvested acreage increased by 3.1% and 7.9% for Randolph and Jay counties respectively.

The grain crops have increased for corn and soybeans but have decreased for wheat and oats in both counties. Livestock numbers for beef cattle, dairy cattle, and sheep decreased for both counties during this ten-year period. Hog numbers in Randolph County decreased where as Jay County had an increase in hogs.

The most impressive trend in the two counties agricultural summaries was the increase in the market value of agriculture products sold. Randolph County increased by 24% to \$67.7 million and Jay County increased 49% to \$83.2 million. These data demonstrate that area farms, although fewer in number, are running more efficiently and productively. Tables 4 and 5 summarize the agricultural data from 1987, 1992 and 1997.

Table 4

RANDOLPH COUNTY AGRICULTURE SUMMARY
(Source: Agriculture Census for Randolph County, Indiana)

Agriculture Highlight	1997	1992	1987	10-year change (%)
Farms (number)	851	936	1,074	(20.8)
Land in farms (acres)	223,817	236,436	244,226	(8.4)
Land in farms – average size of farm (acres)	263	253	227	15.8
Total cropland (farms)	799	868	1,023	(21.9)
Total cropland (acres)	202,017	213,645	217,323	(7.0)
Total harvested cropland (farms)	707	825	977	(27.6)
Total harvested cropland (acres)	187,956	196,230	182,240	3.1
Irrigated land (acres)	90	35	Withheld	
Market value of agriculture products sold (\$1,000)	67,766	65,951	54,844	23.6
Cattle and calves inventory (number)	7,862	11,531	12,699	(38.1)
Beef cows (number)	1,850	2,283	3,031	(40.0)
Milk cows (number)	845	1,312	1,502	(43.7)
Hogs and pigs inventory (number)	50,936	70,528	70,723	(28.0)
Sheep and lambs inventory (number)	1,039	1,117	1,204	(13.7)
Corn for grain or seed (bushel)	8,769,232	10,224,447	7,838,431	11.9
Wheat for grain (bushels)	527,826	580,190	732,057	(27.9)
Oats for grain (bushels)	50,176	65,143	136,691	(63.3)
Soybeans for beans (bushels)	3,940,478	4,060,628	3,581,115	10.0

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Table 5

JAY COUNTY AGRICULTURE SUMMARY
(Source: Agriculture Census for Jay County, Indiana)

Agriculture Highlight	1997	1992	1987	10-year change (%)
Farms (number)	839	852	922	(9.0)
Land in farms (acres)	179,794	182,836	188,637	(4.7)
Land in farms – average size of farm (acres)	214	215	205	4.4
Total cropland (farms)	792	814	864	(8.3)
Total cropland (acres)	157,345	163,094	163,113	(3.5)
Total harvested cropland (farms)	659	772	824	(20.0)
Total harvested cropland (acres)	140,899	141,532	130,597	7.9
Irrigated land (acres)	202	195	7	2785.7
Market value of agriculture products sold (\$1,000)	83,241	63,949	55,866	49.0
Cattle and calves inventory (number)	8,873	11,122	13,070	(32.1)
Beef cows (number)	1,136	1,138	1,787	(36.4)
Milk cows (number)	2,082	2,699	3,047	(31.7)
Hogs and pigs inventory (number)	53,052	56,335	41,993	26.3
Sheep and lambs inventory (number)	670	1,215	1,052	(36.3)
Corn for grain or seed (bushel)	6,464,525	6,339,208	5,019,598	28.8
Wheat for grain (bushels)	367,008	354,342	585,023	(37.3)
Oats for grain (bushels)	51,833	84,547	84,561	(38.7)
Soybeans for beans (bushels)	2,713,945	2,683,771	2,213,761	22.6

2.0 WATERSHED CHARACTERISTICS

This chapter characterizes the watershed's land use and cover, wetland types and prevalence, demographics, and historical data on water quality, wildlife and institutions.

2.1 LAND USE AND COVER

The study area is dominated by agricultural lands, with 83% of the land planted in corn, soybeans and other crops. Very little of the land is urbanized. Pasture and grasslands comprise 10% of the watershed, and 4% is forested. Exhibit 6 and Table 6 below present a further breakdown of the land use and cover.

Table 6

LAND USE
(Source: Indiana GAP Database)

Land Use	Area (acres)
Urban High Density	16
Urban Low Density	49
Agriculture Row Crop	42,357
Agriculture Pasture/Grassland	5,300
Shrubland	190
Woodland	28
Forest Deciduous	2,230
Forest Evergreen	9
Wetland Forest	895
Wetland Shrubland	27
Wetland Herbaceous	82
Wetland Sparsely Vegetated	4
Open Water	20
Total	51,207

Corn, soy beans, wheat, and hay are the most common crops grown within the study area. Tillage systems in use on Randolph County farms are discussed in Chapter 5. Randolph

County had 851 farms totaling 223,817 acres in 1997, and Jay County had 839 farms totaling 179,794 acres. Other agricultural statistics for Randolph and Jay Counties are given in Table 7.

Table 7

AGRICULTURAL STATISTICS FOR JAY AND RANDOLPH COUNTIES

(Source: Indiana Agriculture Statistical Service)

	Jay County	Randolph County
Corn Planted (acres)	64,300	80,800
Soy Beans Planted (acres)	85,300	104,200
Winter Wheat Planted (acres)	12,200	11,000
Hay Harvested (acres)	7,800	6,200
Pig Crop	70,900	118,400
Cattle	8,800	7,800

Note: All statistics based on 1998 data, except for the pig crop numbers which are based on 1994 data and the cattle numbers which are based on 1999 data.

2.2 WETLANDS

Prior to settlement by European immigrants, much of the study area was wetland. Today, there are very few wetlands. There are 930 wetland acres of the 51,207 total acres of land (<2%). Table 8 shows acreages of wetlands in each subwatershed in the study area.

Forested wetlands account for the majority of the wetlands (89.2%). Most of the wetlands that historically existed within the county have had drainage tiles installed to remove the saturated conditions, so that row crops could be planted. The original vegetation has been cleared and the hydrology altered to increase agricultural productivity. Wetlands that remain are lowland areas adjacent to streams and small wetland depressions (Exhibit 7).

Table 8

WETLAND AREAS IN THE SUBWATERSHEDS
(Source: Indiana GAP Database)

Subwatershed	Total Area (ac)	Wetlands (ac)	Percent Wetlands
Clear Creek N	1,871	30	1.60%
Clear Creek	10,830	262	2.43%
Goshen Creek	5,172	113	2.18%
Harshman Creek	8,657	149	1.72%
Jordon Creek	5,624	85	1.51%
Mitchell Ditch	3,404	29	0.85%
Miller Creek N	4,515	111	2.46%
Miller Creek	6,496	74	1.14%
Mud Creek	4,638	76	1.64%

2.3 DEMOGRAPHICS AND DEVELOPMENT TRENDS

In 1998, Randolph County had an estimated population of 27,628, of which 51% were females and 49% were males. The population was 98.4% Caucasian, 1% Hispanic, 0.2% Black, 0.2% Asian and Pacific Islander, and 0.2% American Indian, Eskimo and Aleut. The population of Randolph County is projected to reach 28,360 by the year 2010, a 2.7% population growth over 12 years. Randolph County has a labor force of 11,980 and an unemployment rate of 8.7%. The median household income is \$27,568 and the per capita personal income is \$19,005. Of the 15% of the county's population living in poverty, 35% are under age 18. Approximately 1.7% of the county's population receives welfare.

The estimated 1998 population of Jay County was 21,729, of which 51% were female and 49% were males. The population was 98.2% Caucasian, 1% Hispanic, 0.2% Black, 0.5% Asian and Pacific Islander, and 0.1% American Indian, Eskimo and Aleut. The population of Jay County is projected to reach 22,335 by the year 2010, a 2.8% population growth over 12 years. The number of people comprising Jay County's labor force is 12,200, and the county has an unemployment rate of 4.8%. The median

household income is \$26,847 and the per capita personal income is \$17,067. Of the 13.4% of the county's population living in poverty, 34.5% are under age 18. Approximately 0.6% of the population in Jay County receives welfare.

2.4 HISTORICAL WATER QUALITY

The US EPA water quality database STORET (STOrage and RETrieval) contains limited data for the study area. In addition to STORET, we received more recent data collected by IDEM for the study area, but not yet entered into STORET. Exhibit 8 reprints all historical water quality data. Long-term data are available for dissolved oxygen, 5-day biochemical oxygen demand (BOD), suspended solids, some nutrients and several metals (Exhibits 9, 10 and 11).

The only STORET site in the study area with sufficient data to examine long term water quality trends is Station 171430, Mississinewa River at County Road 133E, near Ridgeville, at river mile 99.49. Between June 1979 and December 1999, this site was regularly sampled on 231 occasions. Tables 9 through 13 include five-year averages and ranges for some key indicators. Table 9 shows trend data for suspended solids (TSS). With the U.S. Department of Agriculture (USDA) Conservation Reserve, LARE, and other soil conservation programs put in place in the 1980s, one would expect to see water quality benefits. While there are many factors that can imply false trends (sampling frequency, analytical methods, detection limits, etc.), reductions in suspended solids are not apparent. Exhibit 9 graphically depicts TSS for the entire dataset.

Table 9

LONG-TERM SUSPENDED SOLIDS CONCENTRATIONS (mg/L)
IN THE MISSISSINEWA RIVER NEAR RIDGEVILLE, IN

Period	N	Mean	Maximum	Minimum
1975-1979	7	64	240	2
1980-1985	56	74	1,200	1
1986-1989	48	23	208	<1
1990-1995	72	24	396	<1
1996-1999	48	71	604	<3

Trends in dissolved oxygen DO and 5-day biochemical oxygen demand (BOD) provide insight into ecosystem stressors. Table 10 presents long term DO data, clearly showing trends of increasing means and maxima. BOD concentrations have decreased in recent years (Table 11), perhaps reflecting improvements in wastewater treatment in Union City and other municipal point source dischargers. Increasing DO maxima are an indirect indicator of ecosystem stress. Concentrations as high as 17.6 mg/L indicate supersaturation of the water with oxygen as a result of algae photosynthesis.

Table 10

LONG-TERM DO CONCENTRATIONS (mg/L)
IN THE MISSISSINEWA RIVER NEAR RIDGEVILLE. IN

Period	N	Mean	Maximum	Minimum
1975-1979	7	9.0	11.7	7.0
1980-1985	55	8.9	13.8	5.2
1986-1989	47	9.7	15.5	2.8
1990-1995	57	10.2	17.6	4.5
1996-1999	48	10.3	15.1	4.2

Table 11

LONG-TERM BOD CONCENTRATIONS (mg/L)
IN THE MISSISSINEWA RIVER NEAR RIDGEVILLE, IN

Period	N	Mean	Maximum	Minimum
1975-1979	7	2.9	9.0	1.1
1980-1985	54	1.7	4.2	<1.0
1986-1989	24	1.7	5.6	<1.0
1990-1995	34	1.4	2.6	<1.0
1996-1999	24	2.5	12.0	<1.0

In low-gradient streams like the Mississinewa, oxygen supersaturation is an indicator of nutrient enrichment. This is apparent in the phosphorus (Table 12), ammonia nitrogen (Table 13) and nitrate data. Clear trends in the concentration of phosphorus are not apparent. Ammonia concentrations are clearly declining, again, possibly attributable to

improved point source controls. However, these nutrient concentrations are sufficiently high to cause algae blooms and oxygen supersaturation.

Table 12

LONG-TERM PHOSPHORUS CONCENTRATIONS (mg/L)
IN THE MISSISSINEWA RIVER NEAR RIDGEVILLE, IN

Period	N	Mean	Maximum	Minimum
1975-1979	7	0.28	0.44	0.14
1980-1985	56	0.28	0.80	0.05
1986-1989	48	0.45	2.70	0.07
1990-1995	72	0.16	0.79	0.03
1996-1999	48	0.22	0.91	0.06

Table 13

LONG-TERM AMMONIA NITROGEN CONCENTRATIONS (mg/L) IN THE MISSISSINEWA RIVER NEAR RIDGEVILLE, IN

Period	N	Mean	Maximum	Minimum
1975-1979	7	0.14	0.20	0.10
1980-1985	56	0.11	0.50	0.01
1986-1989	48	0.13	0.50	0.10
1990-1995	71	0.12	0.70	0.10
1996-1999	48	0.08	0.40	<0.10

2.5 FISH

The study area's fishery is limited to small streams and ponds. The watershed has been subjected to extensive agricultural practices. Straightening of streams and the draining of wetland areas has degraded the aquatic habitat from its original quality and this has affected the fish community. Fishes that were collected in the Mississinewa and Little Mississinewa Rivers during the IDNR 1998 fisheries survey are listed in Table 14. All of the species listed are native to the watershed with the exception of the common carp.

Table 14

FISHES PRESENT IN THE MISSISSINEWA AND LITTLE MISSISSINEWA RIVERS

(Source: Braun, 1999)

Scientific Name	Common Name	Mississinewa River	Little Mississinewa River	
Dorosoma cepedianum	Gizzard shad	X		
Esox americanus	Grass pickerel	X		
Cyprinus carpio	Common carp	X		
Notemigonus crysoleucas	Golden shiner	X	X	
Semotilus atromaculatus	Creek chub	X	X	
Campostoma anomalum	Central stoneroller	X	X	
Phenacobius mirabilis	Suckermouth minnow	X	X	
Luxilus chrysocephalus	Striped shiner	X	X	
Lythrurus umbratilis	Redfin shiner	X	X	
Cyprinella spiloptera	Spotfin shiner	X		
Cyprinella whipplei	Steelcolor shiner	X		
Pimephales promelas	Fathead minnow		X	
Pimephales notatus	Bluntnose minnow	X	X	
Ericymba buccata	Silverjaw minnow	X	X	
Carpiodes cyprinus	Quillback	X		
Catostomus commersoni	White sucker	X	X	
Minytrema melanops	Spotted sucker	X		
Erimyzon oblongus	Creek chubsucker	X	X	
Hypentelium nigricans	Northern hog sucker	X		
Moxostomus duquesnei	Black redhorse	X		
Moxostoma erythrurum	Golden redhorse	X		
Moxostoma anisurum	Silver redhorse	X	X	
Ictalurus punctatus	Channel catfish	X		
Ameiurus natalis	Yellow bullhead	X	X	
Pylodictis olivaris	Flathead catfish	X		
Noturus flavus	Stonecat	X	X	
Noturus gyrinus	Tadpole madtom	X	X	
Noturus miurus	Brindled madtom	X		
Fundulus notatus	Blackstripe topminnow	X	X	
Cottus bairdi	Mottled sculpin	X	X	

Table 14

FISHES PRESENT IN THE MISSISSINEWA AND LITTLE MISSISSINEWA RIVERS

(Source: Braun, 1999)

Scientific Name	Common Name	Mississinewa River	Little Mississinewa River	
Morone chrysops	White bass	X		
Pomoxis nigromaculatus	Black crappie	X		
Pomoxis annularis	White crappie	X		
Ambloplites rupestris	Rock bass	X		
Micropterus salmoides	Largemouth bass	X	X	
Micropterus dolomieu	Smallmouth bass	X		
Lepomis cyanellus	Green sunfish	X	X	
Lepomis macrochirus	Bluegill	X	X	
Lepomis megalotis	Longear sunfish	X	X	
Lepomis humilis	Orangespotted sunfish	X		
Stizostedion vitreum	Walleye	X		
Percina maculata	Blackside darter	X	X	
Percina phoxocephala	Slenderhead darter	X		
Percina caprodes	Logperch	X	X	
Etheostoma nigrum	Johnny darter	X	X	
Etheostoma blennioides	Greenside darter	X	X	
Etheostoma caeruleum	Rainbow darter	X	X	
Etheostoma spectabile	Orangethroat darter		X	
Aplodinotus grunniens	Freshwater drum	X		

2.6 THREATENED AND ENDANGERED SPECIES

The threatened and endangered species are protected under the Endangered Species Act (16 USC 1531 et seq.) of 1973. The goal of the act is to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to restore all listed species to the point where their numbers make them viable self-sustaining members of their ecological communities.

We contacted the DNR Division of Nature Preserves with a request for information on the presence of threatened of endangered species and high quality natural communities within the study area. Table 15 lists the threatened and endangered species and the high quality natural communities for the upper Mississinewa River watershed. The barn owl, orange coneflower and heavy sedge are widespread outside the state, but within Indiana, they are listed as endangered. The Indiana bat is on both state and federal lists as endangered.

THREATENED AND ENDANGERED SPECIES AND HIGH QUALITY NATURAL
COMMUNITIES BELIEVED TO BE IN THE STUDY AREA

Table 15

(Source: IDNR, 2000)

	(Source: IDINE, 2000)									
Туре	Species Name	Common Name	Federal Status	State Status	Heritage Global Rank	Heritage State Rank	Date			
Bird	Tyto alba	Barn Owl	Not listed	Endangered	Wide spread	Imperiled	1979			
Mammal	Myotis sodalis	Indiana Bat	Endangered	Endangered	Imperiled	Critically imperiled	1990			
Forest	Forest – Flatwoods Central Till Plain	Central Till Plain Flatwoods	Not listed	Significant	Rare	Imperiled	1980			
Vascular Plant	Rudbeckia fulgida var fulgida	Orange Coneflower	Not listed	Rare	Widespread	Imperiled	1938			
Vascular Plant	Carex gravida	Heavy Sedge	Not listed	Endangered	Widespread	Critically imperiled	1916			

3.0 WATERSHED BIOASSESSMENT

Water quality data was collected and bioassessments were performed in the study area during May 2000. Chemical, biological and habitat surveys were performed at our six bioassessment sampling stations (UM1, UM2, UM3, UM4, UM5, and UM6). These samples were analyzed and used to characterize tributary subbasins.

3.1 CHEMICAL QUALITY

Water quality samples were collected in the study area at six subwatershed sites. Samples were analyzed by Environmental Health Labs of South Bend, Indiana for conductivity, *E. coli*, total Kjeldahl nitrogen, nitrate+nitrite nitrogen, pH, total phosphorus, dissolved phosphorus, and turbidity. Field measurements were taken for water temperature, conductivity, pH, dissolved oxygen and flow. One set of samples was collected during the bioassessment surveys to characterize low or baseflow conditions. A second set of samples will be collected to characterize high flow conditions.

3.1.1 Conductivity

Conductivity is the ability of water to carry an electric current and depends on the concentration of dissolved ions. It is an indirect measure of the dissolved solids in the water. Typical dissolved solids include salts, organic materials, and nutrients. For the baseline samples, field measurements of conductivity ranged from 686 mhos/cm in Harshman Creek to 781 mhos/cm in Miller Creek. Lab analysis of the water reported the conductivity range to be 680 mhos/cm in Harshman Creek through 730 mhos/cm in Miller Creek for the baseflow samples. Exhibit 12 shows the conductivity at each sampling location during baseflow.

3.1.2 Dissolved Oxygen

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in the water column available to support aquatic life. DO levels near the saturation point indicate conditions favorable for a variety of life, while water with low DO levels is only able to support a few species. Many species suffer if DO levels fall below 3-4 mg/L. Streams absorb oxygen directly from the air and from aquatic plants undergoing photosynthesis. Supersaturated, DO concentrations (>100%) generally indicate nutrient enrichment, with photosynthesis causing the very high levels. Indiana's surface water quality standards

dictate that DO levels shall average at least 5 mg/L per day and at no time should levels fall below 4 mg/L. Field measurements of dissolved oxygen were taken at each sampling point. DO ranged from 14.8 mg/L in Miller Creek to 25.4 mg/L in Mud Creek, and all DO levels measured were well above the standard of 5 mg/L, indicating that the streams have enough oxygen to support diverse aquatic communities. The percent DO saturation ranged from 147% in Harshman Creek to 274% in Mud Creek. Oxygen supersaturation in low-gradient streams generally indicates nutrient enrichment in the waters. The high concentrations of DO are a result of photosyntheses from abundant attached filamentous algae. Exhibit 13 shows the percent saturation of dissolved oxygen level at each sampling location.

3.1.3 Temperature

Water temperature is important to aquatic life in a stream. As temperatures in the stream rise, less oxygen is available for aquatic organisms. Increased temperatures can cause an increase in metabolic and reproductive rates throughout the food chain. Some species have a specific range of temperatures in which they will survive, so large variations in temperature could threaten aquatic communities. Field measurements of temperature were measured for the baseline samples. Temperature ranged from 13.2°C in Miller Creek to 17.7°C in Mud Creek.

3.1.4 pH

Water's hydrogen ion concentration is expressed as pH. Measurements below neutral, pH 7.0, indicate higher hydrogen ion concentrations and that the water is acidic. Conversely, pH values above 7.0 show that the water is basic. Many aquatic organisms are sensitive to fluctuations in pH, and their reproduction processes are impeded under very acidic or very basic conditions in the water. Indiana's surface water standard dictate that pH should be in the range of 6–9, and variations exceeding nine will be permitted if associated with photosynthetic activity. Field measurements of pH ranged from 8.08 in Goshen Creek to 8.69 in Jordon Creek, and were well within the standard. These values indicate that the waters of the upper Mississinewa Watershed are slightly basic.

3.1.5 Coliform Bacteria

Escherichia coli is the most widely known member of the coliform group of bacteria. E. coli is abundant in fecal matter and is often used as an indicator of sanitary discharges and pathogenic organisms. E. coli is estimated colony forming units (cfu) per 100ml of sample. Indiana's standard for recreational waters state "E. coli bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) colony forming units per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) colony forming units per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period" (IAC 327 2-1-6). Concentrations of E. coli for the baseline samples taken on June 15 ranged from 10 cfu/100ml in Miller Creek and Jordon Creek to 70 cfu/100mL in Mud Creek. These are below Indiana's water quality standard for recreational waters. Exhibit 14 shows the E. coli levels from June 15 at each sampling location. Results from the June 30 E. coli samples are all in excess of the Indiana state water quality standards.

3.1.6 Nitrogen

Nitrogen is also an essential nutrient in plant and animal growth, however in high concentrations it can inhibit such development. Natural waters contain nitrogen in the form of organic (or biomass) nitrogen, or in inorganic forms such as nitrate (NO₃), or nitrite (NO₂). In aerobic waters nitrate is usually the predominant form. Nitrogen can enter the stream through stormwater runoff from lands applied with fertilizer. In this study, nitrate and nitrite, and total Kjeldahl nitrogen (TKN) were measured. TKN is a measure of organic plus ammonia nitrogen.

The surface water quality standard set by the State for nitrite and nitrate is a maximum of 10 mg/L. Nitrate and nitrite values for the baseflow samples ranged from 3.6 mg/L in Harshman Creek to 16.0 mg/L in Jordon Creek. The Jordon Creek sample is the only one exceeding 10 mg/L. TKN in the baseflow samples ranged from 1.7 mg/L in Goshen Creek to 4.5 mg/L in Jordon Creek. Exhibit 15 shows the nitrite levels at each sampling location and Exhibit 16 shows the TKN levels.

3.1.7 Phosphorus

Phosphorus is also an essential nutrient for plant and animal growth. Excessive concentrations of phosphorus in the water column can lead to eutrophication of the stream. Both dissolved and total phosphorus were analyzed in this study. Dissolved phosphorus is the portion of total phosphorus that is operationally defined as that portion passing through a 0.45-µm-pore filter. A major source of dissolved phosphorus generation in a stream is decomposition of organic matter. Dissolved phosphorus has a short half-life and concentrations often vary widely over a short time. For this reason, total phosphorus is more commonly used as a measure of the trophic status. Total phosphorus is a measure of both particulate and dissolved phosphorus. A mechanism by which total phosphorus enters the stream is through land-applied fertilizer. Phosphorus particles become bound to the soil, and as surface runoff carries these particles to the stream, the phosphorus tends to remain in particulate form. The range of total phosphorus in the baseflow samples was from 0.05 mg/L in Jordon Creek and Goshen Creek to 0.15 mg/L in Miller Creek. Exhibit 17 shows the total phosphorus levels at each sampling location and Exhibit 18 shows the dissolved phosphorus levels.

3.1.8 Turbidity

Nephelometric Turbidity Units (NTU) are the unit of measure for turbidity, which indicates the intensity of light scattering by dissolved and suspended materials in water. Turbidity is related to soil erosion, particulate matter from aquatic life, and suspension of bottom sediments due to wind, wave action or aquatic animals. High turbidity in a waterbody is not aesthetically pleasing and threatens the diversity of aquatic organisms. Turbidity was measured at each monitoring point, and ranged from 1.2 NTU in Miller Creek to 4.3 NTU in Goshen Creek in the baseflow samples.

3.1.9 Baseflow Samples

Water samples were taken during baseflow conditions at the time of the bioasessment survey. The six largest subwatersheds in the study area were selected for sampling. Subwatershed sampling points were located on the tributaries near their confluences with the Mississinewa River. These sampling locations were chosen to reflect upstream point and non-point pollution sources in the subwatersheds.

Water samples were collected in polyethylene bottles pre-cleaned and supplied by the laboratory. Samples were collected prior to collecting biota or measuring flows. Following labeling, the bottles were placed on ice in a cooler, where they were kept until delivered to the laboratory later that day. Field water quality parameters were measured using a YSI model 6920 water quality data logger. Turbidity was measured using a Cole Parmer model 08391-50 portable turbidity meter. Flow measurements were taken using a Marsh McBirney model 201 portable flow meter.

Results from stream flow measurements made immediately following sample collection are given in Table 16.

Table 16

BASEFLOW STREAM DISCHARGE

Site	Subwastershed	Discharge (ft ³ /sec)		
UM1	Mud Creek	2.3		
UM2	Clear Creek	2.1		
UM3	Miller Creek	1.0		
UM4	Harshman Creek	2.3		
UM5 Jordon Creek		0.7		
UM6	Goshen Creek	1.9		

Water quality parameters measured in the field on June 15 and 16 are given in Table 17. Water samples collected on June 15 were shipped to Environmental Health Laboratories of South Bend, Indiana for analysis. A second set of baseflow *E. coli* samples taken on June 30 were collected by SWCD staff and analyzed by Sherry Laboratory of Muncie, Indiana. The results of laboratory analyses are shown in Tables 18 and 19 and the laboratories reports can be found in Appendix B.

Table 17

BASEFLOW IN-SITU WATER QUALITY RESULTS

Site	Subwatershed	Temp (C)	Conductivity (umhos)	pН	DO (mg/L)	% DO Saturation
UM1	Mud Creek	17.7	711	8.49	25.4	274
UM2	Clear Creek	17.1	697	8.50	18.2	194
UM3	Miller Creek	13.2	781	8.33	17.4	170
UM4	Harshman Creek	14.0	686	8.21	14.8	147
UM5	Jordon Creek	14.2	707	8.69	20.6	205
UM6	Goshen Creek	15.7	709	8.08	23.7	239

Table 18
RESULTS OF LABORATORY ANALYSES FROM JUNE 15, 2000

Site	Subwatershed	E. coli	Kjeldahl Nitrogen	Nitrate+ Nitrite	pН	Total Phosphorus	Dissolved Phosphorus	Turbidity
		cfu/100ml	mg/L	Mg N/L		mg P/L	mg P/L	NTU
UM1	Mud Creek	70	2.1	9.4	8.3	0.09	0.05	1.9
UM2	Clear Creek	20	2.3	7.8	8.3	0.08	< 0.05	1.5
UM3	Miller Creek	10	2.2	5.9	8.5	0.15	0.13	1.2
UM4	Harshman Creek	50	1.9	3.6	8.2	0.06	< 0.05	1.9
UM5	Jordon Creek	10	4.5	16.0	9.0	0.05	0.05	3.1
UM6	Goshen Creek	30	1.7	9.9	8.2	0.05	0.09	4.3

Table 19
COLIFORM RESULTS OF JUNE 30, 2000

Site	Subwatershed	E. coli (cfu/100ml)
UM1	Mud Creek	7,400
UM2	Clear Creek	810
UM3	Miller Creek	840
UM4	Harshman Creek	720
UM5	Jordon Creek	1,320
UM6	Goshen Creek	340

All of the *E. coli* results from June 30 exceeded the Indiana state water quality standards. In any one time sampling scheme, the *E. coli* counts are not to exceed 235 cfu/100ml. Bacteria levels within waterways are quite variable, and on June 30 all of the sampling stations within the watershed demonstrated high bacteria counts.

3.1.10 High Flow Samples

The summer 2000 drought did not allow collection of high flow water quality data until October 6 (Table 20). The same six sites were sampled, and analyzed for *E. coli*, TKN, conductivity, pH, phosphorus and turbidity. All six samples greatly exceeded the coliform bacteria standard, with Mud Creek and Clear Creek being the highest. Mud Creek also shows high TKN values, suggesting significant source of organic (and/or ammonia) nitrogen loading in this subwatershed during wet weather. This evidence, together with the coliform data, suggest that improper animal waste management in the Mud Creek subwatershed.

Turbidity values for the storm samples are quite high, averaging 85 NTU. Baseflow samples averaged 2.3 NTU. Turbidity is commonly correlated with high streamflows due to its relation to soil erosion and resuspension of bottom and bank sediments.

The phosphorus data in Table 20 does not include dissolved phosphorus results. Dissolved phosphorus samples were not filtered by the laboratory, which resulted in duplicate total phosphorus samples per location. The average of these results are provided in Table 20.

Kieldahl Total Site Subwatershed E. coli Conductivity пΗ Turbidity Nitrogen Phosphorus cfu/100ml mg/L (umhos) mg P/L NTU UM1 Mud Creek 54,000 10.5 430 7.6 0.60 74 UM2 Clear Creek 74,000 2.41 400 7.7 0.42 100 UM3 Miller Creek 10,200 2.14 470 7.7 0.34 96 UM4 Harshman Creek 3.300 3.42 450 7.8 0.35 92 UM5 Jordon Creek 14,000 3.04 590 7.8 0.70 60 UM6 Goshen Creek 1,080 3.44 0.52** 470 7.5 88

Table 20
RESULTS OF LABORATORY ANALYSES FROM OCTOBER 6, 2000

3.2 PHYSICAL HABITAT

Physical habitat was evaluated utilizing the Ohio EPA's Qualitative Habitat Evaluation Index (OEPA 1989). A 300-foot section of each of the six subwatershed streams was inspected by a two-person field team. During the Qualitative Habitat Evaluation Index (QHEI) evaluation, scores are recorded on the data sheets for seven physical habitat metrics and the results are summed. These qualitative parameters include: substrate, instream cover, channel morphology, riparian zone and bank erosion, pool and glide quality, riffle and run quality, and gradient.

QHEI reflects the quality of stream physical habitat. In this procedure, the highest scores are assigned to the habitat parameters that have been shown to be correlated with streams having high biological diversity and biological integrity. Progressively lower scores are assigned to less desirable habitat features.

Table 21 and Exhibit 19 show the QHEI results and Appendix C contains the QHEI field data sheets. Photographs taken during the field investigation are contained in Appendix D.

^{**} analysis performed outside of holding time

Table 21

QUALITATIVE HABITAT EVALUATION INDEX

Site	Subwatershed	Substrate	Cover	Channel	Riparian	Pool	Riffle	Gradient	QHEI
UM1	Mud Creek	14	13	13.5	10	6	2	8	66.5
UM2	Clear Creek	16	13	12	14	5	4	10	74
UM3	Miller Creek	16	6	10.5	8	4	5	6	55.5
UM4	Harshman Creek	14	13	13	5	9	4	10	68
UM5	Jordon Creek	14	9	10.5	8	7	6	6	60.5
UM6	Goshen Creek	15	14	13.5	9	7	3	6	67.5

Clear Creek had the highest habitat score of the six streams sampled. This was due to receiving the highest scores in three of the seven metrics, including the riparian habitat score. Within this metric, erosion/runoff – flood plain quality is evaluated. Higher scores are given to stream banks that are forested. Clear Creek was the only stream that had both banks forested. Goshen Creek has one bank forested.

Miller Creek had the lowest scores for four of the seven metrics: instream cover, channel morphology, pool/glide quality and gradient. Miller Creek was the only site that did not possess any deep pool habitat or rootwads, had no sinuosity, and had a maximum depth less than 40 cm (15.7 inches). All of these attributes contributed to Miller Creek having the poorest habitat score.

Agricultural land uses without conservation buffers along stream corridors have higher rates of sedimentation than other land uses. Fine silt particles are transported by overland flow to streams where they are carried by the flow until deposited on the substrate. The adverse effects of sedimentation include burial of aquatic vegetation, macroinvertebrates and substrate interstial spaces. In the QHEI, there are two means of scoring substrate quality. One involves the amount of silt cover on the substrate. The second is the embeddness by silt particles on rocks and leaves on the surface of the substrate. QHEI scoring of substrate quality is tabulated below in Table 22. Again, higher values are indicative of increase in habitat quality.

Table 22
SUBSTRATE OUALITY SCORING

Site	Subwatershed	Silt Cover (points)	Extent of Embeddness (points)
UM1	Mud Creek	Silt normal (0)	Low (0)
UM2	Clear Creek	Silt normal (0)	Low (0)
UM3	Miller Creek	Silt free (+1)	None (+1)
UM4	Harshman Creek	Silt normal (0)	Low (0)
UM5	Jordon Creek	Silt normal (0)	Low (0)
UM6	Goshen Creek	Silt normal (0)	None (+1)

Miller Creek gained habitat quality points for having silt free substrate condition and no embeddness. Goshen Creek gained habitat quality points for having no embeddness. All of the other subwatershed streams had normal siltation and low levels of embeddness.

3.3 MACROINVERTEBRATE COMMUNITIES

The US EPA's Rapid Bioassessment Protocol II (RBP II) utilizes the systematic field collection and analysis of major benthic taxa. This protocol is appropriate for prioritizing sites for more intensive evaluation.

RBP II incorporates the concept of benthic analysis at the family taxonomic level. The technique utilizes field sorting and identification. The biological survey component of RBP II focuses on standardized sampling of benthic macroinvertebrates, supplemented by a cursory field observation of other aquatic biota such as periphyton, macrophytes, slimes and fish. The collection procedure provides representative samples of the macroinvertebrate fauna from riffle and run habitat types, and is supplemented with separate Course Particulate Organic Matter (CPOM) samples for the analysis of shredders and nonshredders. RBP II focuses on the riffle/run habitat because it is the most productive habitat available in stream systems and includes many pollution-sensitive taxa of the scraper and filtering collector functional feeding groups.

Collection of macroinvertebrates included quantitative and qualitative sampling methods. Quantitative sampling included triplicate sampling with a Surber sampler in riffles and runs. Qualitative sampling included rock picking for clinging individuals and netting individuals swimming within the water column. CPOM was collected from available detritus, leaves and sticks and individuals were counted until at least 50 individuals were obtained to evaluate the ratio of shredders to the total number of individuals collected. All macroinvertebrates collected are listed on data sheets reprinted in Appendix C. Table 23 and Exhibits 20 through 24 provide the macroinvertebrate survey results.

Table 23

MACROINVERTEBRATE MATRIX SCORES

Parameter	Mud	Clear	Miller	Harshman	Jordon	Goshen
	Creek	Creek	Creek	Creek	Creek	Creek
Taxa Richness	12	11	11	14	10	9
Family Biotic Index	5.641	4.648	5.625	3.744	6.463	4.013
Ratio of Scraper/Filterer	-	-	-	3.4	1.0	0.1
Ratio of EPT/Chironomidae	0.891	0.631	0.714	2.655	0.077	3.333
% Contribution Dominant Family	0.389	0.444	0.474	0.239	0.320	0.452
EPT Index	2	2	3	6	1	2
Ratio of Shredder/Nonshredder	0.415	0.877	-	0.020	_	0.040
Total Number Collected	208	144	133	138	122	146

Taxa Richness is simply the total number of families present. This value generally increases with increasing water quality, habitat diversity and habitat suitability. Modified Family Biotic Index (FBI) was developed to detect organic pollution and is based on the original species level index developed by Hilsenhoff in 1982. The modified FBI is a product of pollution tolerance values for family levels and the quantity of individuals within each family. Pollution tolerance values range from 0 to 10 for families and increase as water quality decreases.

The ratio of scraper to filtering collector reflects the riffle/run community food base. The relative abundance of scrapers and filtering collectors in the riffle/run habitat is indicative of periphyton community composition, availability of fine particulate organic material and the availability of attachment sites for filtering. Scrapers increase with an increase in diatom abundance and decrease in filamentous algae and aquatic mosses. Filamentous

algae and aquatic mosses provide good attachment sites for filtering collectors and the organic enrichment often responsible for filamentous algae growth can also provide fine particulate organic material that is utilized by filtering collectors. Filtering collectors are also sensitive to toxicants bound to fine particles and should be the first group to decrease when exposed to steady sources of such bound toxicants.

The ratio of EPT (Ephemeroptera-mayflies, Plecoptera-stoneflies and Trichoptera-caddisflies) and Chironomidae (midges) reflects good biotic condition if the sensitive groups (EPT's) demonstrate a substantial representation. If the Chironomidae have a disproportionately large number of individuals in comparison to the sensitive groups then this situation is indicative of environmental stress. Percent Contribution of Dominant Family uses the abundance of the numerically dominant taxon relative to the total number of organisms as an indication of community balance at the family level.

EPT Index value summarizes the taxa richness within the taxa groups that are generally considered pollution sensitive and will generally increase with increasing water quality. This metric is the total number of distinct taxa within the groups Ephemeroptera, Plecoptera and Trichoptera. Ratio of Shredder functional feeding group relative to the abundance of all other functional feeding groups allows for the evaluation of potential impairment. Shredders are sensitive to riparian zone impacts and are particularly good indicators of toxic effects when the toxicants involved are readily adsorbed to the CPOM and either affect microbial communities colonizing the CPOM or the shredders directly (USEPA 1989).

3.4 SUMMARY OF TRIBUTARY HEALTH

There are nine subwatersheds in the study area. Streams draining six of these were sampled, as described above. Key indicators are judged to be coliform bacteria, nutrient concentrations, turbidity, the QHEI scores and FBI, the Family Biotic Index. The FBI was selected as the key benthic indicator as it incorporates both diversity and pollution tolerance. Recall that higher FBI scores are indicator of an aquatic system under stress.

Table 24 reiterates these data for the six streams sampled. Dry weather (or baseflow) water quality data are shown in Table 24. Harshman Creek is rated least impacted due to its low nutrient concentrations, low FBI score, moderate turbidity and relatively good QHEI habitat score. Goshen Creek also has a relatively low FBI, but showed high

turbidity and inorganic nitrogen concentrations. Jordon, Miller and Mud Creeks are deemed most impacted by nonpoint source pollution.

Table 24
SUMMARY OF TRIBUTARY HEALTH INDICATORS

Site	Subwatershed	E. coli (cfu/100mL)	•	NO ₃ +NO ₂ (mg/L)	Total P (mg/L)	Turbidity (NTU)	QHEI Score	FBI
UM1	Mud Creek	70 – 7,400	2.1	9.4	0.09	1.9	66.5	5.641
UM2	Clear Creek	20 - 810	2.3	7.8	0.08	1.5	74.0	4.648
UM3	Miller Creek	10 – 840	2.2	5.9	0.15	1.2	55.5	5.625
UM4	Harshman Ck	50 – 720	1.9	3.6	0.06	1.9	68.0	3.744
UM5	Jordon Creek	10 – 1,320	4.5	16.0	0.05	3.1	60.5	6.463
UM6	Goshen Creek	30 - 340	1.7	9.9	0.05	4.3	67.5	4.013

4.0 POLLUTION SOURCES

Both natural and human activities can modify the landscape and cause pollutants to enter waterways. Pollution sources are divided into two broad categories: point sources and nonpoint sources. Point sources are traceable to a single point of discharge into the waterway, and are usually regulated by state or federal permits (such as National Pollutant Discharge Elimination System (NPDES) Permits). Municipal treatment plants and industrial facilities are common examples of point source discharges to a waterbody. Nonpoint source pollution comes from the watershed land surface, and can be difficult to trace to any one particular site. Typically, nonpoint source pollutants are transported to the waterbody via stormwater runoff. Sediments and nutrients are common pollutants that are washed from agricultural fields or construction sites during runoff events. In this chapter we summarize point and nonpoint pollution sources in the study area.

4.1 POINT SOURCES

One publicly-owned treatment works in Union City, Indiana, discharges water to the Little Mississinewa River. Although the Little Mississinewa River watershed is out of the study area, it flows into the Mississinewa River and affects its water quality. Several industrial dischargers, including CBS Corporation (NPDES permit number INP000051), Lear Corporation Automotive Systems (NPDES permit number INP000036), and Union City Body Company, Inc. (NPDES permit number INP000021), discharge to the Union City Wastewater Treatment Plant. NPDES permit number IN0020982 was issued to the Union City in November 1995, and expires in October 2000 (US EPA Permit Compliance System). The municipality is required to monitor their effluent for TSS, BOD₅, flow, total residual chlorine, ammonia nitrogen, cyanide, cadmium, chromium, copper, lead, zinc, *E. coli*, and pH. Violations for TSS occurred in March, April and May of 2000, and violations for ammonia nitrogen occurred in March, April, and May 2000.

4.2 NONPOINT SOURCES

The nonpoint sources of pollution to the Mississinewa River are attributable to stormwater runoff from the surrounding watershed. Stormwater runoff can carry considerable sediment and nutrient loading, depending on land use, vegetatve cover and other factors. The principal nonpoint source in the study area watershed is agricultural cropland. Minor sources include animal management units and urban runoff.

To evaluate nonpoint source loadings in the study area tributary watersheds, we reviewed available techniques, selected that most applicable with available resources and applied it. USEPA's 1997 Compendium of Tools for Watershed Assessment and TMDL Development divides watershed models into three categories:

- 1. Simple methods
- 2. Mid-range models
- 3. Detailed models

The simple models typically predict annual loadings of pollutants to a waterbody, based upon empirical loading factors corresponding to watershed characteristics. Mid-range models are also typically based on empirical loading factors, but can provide greater temporal resolution (i.e., continuous simulation) and include site-specific runoff concentration data. Detailed models take a rigorous mechanistic approach to calculate nonpoint source loads, and predict pollutant accumulation and washoff rates in the surface as well as subsurface fate and transport.

To select a model for use, we considered:

- Site specific characteristics
- · Management objectives
- Available resources

Site-specific features for selecting a watershed model include the constituents of interest (nutrients and solids) and the nature of land use (largely agriculture). Available resources include field data for the sites and the time available to devote to the assessments. The effort to appropriately apply a rigorous watershed model would require several years of data collection and analysis. Because of the desire to have a management tool developed in a short time frame and with limited data, it was recognized that a high or mid-level of complexity for the watershed model would not be suitable. Simple methods were considered for the loading models.

The EPA screening procedures (Mills et al., 1985) are recommended as an appropriate simple modeling approach for simulating loads from all nine subwatersheds in the study

area. This approach can be used to predict sediment and nutrient losses using the Universal Soil Loss Equation (USLE), runoff curve number procedure, and loading functions of agricultural nonpoint loads. Detailed calibration of the watershed model is, in fact, not necessary. Model objectives are to discriminate between tributary watershed and to identify problem areas. The relative results of modeling are more informative than the absolute values.

4.2.1 Sediment Loading Estimates

Sediment loadings to the Mississinewa River were computed for each of the nine subwatersheds included the study area. Since the subwatersheds are dominated by agriculture and undeveloped lands, the EPA's Simple Method for Watershed Sediment Yield was used. Sediment loadings were calculated based on rainfall, land use, and soil type within the subwatershed (Mills *et al.*, 1985). The watershed sediment yield due to surface erosion is:

$$Y = s_d \sum_k X_k A_k$$
 Equation (1)

where

Y = annual sediment yield (tons/year)

 $X_k =$ erosion from source area k (tons/ha)

 $A_k =$ area of source area k (ha)

 $s_d =$ watershed sediment delivery ratio

Erosion from each subwatershed was estimated using the Universal Soil Loss Equation (USLE), which is an empirical equation designed to predict average annual soil loss from source areas. The relationship is as follows (Mills *et al.*, 1985):

$$X = 1.29(E)(K)(ls)(C)(P)$$
 Equation (2)

where

X = soil loss (t/ha)

E = rainfall/runoff erosivity index (10² m-ton-cm/ha-hr)

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K = soil erodibility (t/ha per unit of E)

ls = topographic factor

C = cover/management factor

P = supporting practice factor

The erosivity term, E, is dependent upon rainfall data. Average annual values for the United States are presented in the EPA's Water Quality Assessment (1985). For the Mississinewa watershed, the average value is 264 (10² m-ton-cm/ha-hr). Soil erodibility (or "K" values) are a function of soil texture and organic content. Soil type was identified for each subwatershed using the STATSGO database (Exhibit 5). Corresponding K values are shown in Table 25:

SOIL ERODIBILITY "K" VALUES
(Source: STATSGO)

Table 25

•		,
Soil Type	Soil ID	K Value
Blount	IL 0014	0.43
Glynwood	OH 0040	0.43
Miamian	OH 0008	0.32
Sawmill	IL 0084	0.28

The topographic factor, ls, is related to slope angle and slope length by the following relationship:

$$ls = (0.045x)^b (65.41\sin^2\theta + 4.56\sin\theta + 0.065)$$
 Equation (3)

The slope angle θ is obtained from the percent slope, s, by:

$$\theta = \tan^{-1}(s/100)$$
 Equation (4)

Slopes of each soil type were taken from the STATSGO database, and the resulting topographic factors are listed in Table 26.

Table 26

TOPOGRAPHIC FACTORS

(Source: STATSGO)

Soil Type	ls
Blount	0.08
Glynwood	0.08
Miamian	0.08
Sawmill	0.05

The cover/management C factor is a measure of the protection of the soil surface by plant canopy, crops, and mulches. The maximum C value is 1.0, which corresponds to no protection, while a value of 0.0 corresponds to total protection. Published C values were selected from Wischmeier and Smith (1978) based on the land use type (Table 27).

Table 27

C VALUES FOR VARIOUS LAND USES

Land Use	C Value
Other Non-vegetated	0
Urban High Density	0
Urban Low Density	0
Agriculture Row Crop	0.540
Agriculture Pasture/Grassland	0.055
Shrubland	0.055
Woodland	0.055
Forest Deciduous	0.004
Forest Evergreen	0.004
Forest Mixed	0.004
Wetland Forest	0.004
Wetland Woodland	0.055
Wetland Shrubland	0.055
Wetland Herbaceous	0.055
Wetland Sparsely Vegetated	0.067
Water	0

The supporting practice factor P is a measure of the effect of traditional soil conservation practices on erosion from agricultural fields. Purdue Research Foundation's TRANSECT (Version 2.13) program was used to find P factors for the upper Mississinewa watershed, based on its 11-digit HUC code. This database provides easy access to information gathered during surveys of agricultural fields throughout Indiana. TRANSECT includes P values for the study area of 1, which corresponds to no conservation practices. While this is inconsistent with TRANSECT's data on conservation tillage in Jay and Randolph Counties, we opted to use a P factor of 1 in the model. There are no conservation practices data specific to each subwatershed. Our use of unity for the P factor results in an overestimate of soil loss, and is a principal contributing factor to model uncertainty.

The watershed sediment delivery ratio is a measure of the attenuation of sediment through deposition and filtering as it moves from the source areas to the waterbody. EPA guidance (EPA, 1985) suggests that the sediment delivery ratio is a function of the watershed drainage area. Vanoni (1975) published a figure depicting this relationship, and it was used to determine the sediment delivery ratio for each subwatershed. The sediment delivery ratios for the Mississinewa subwatersheds ranged from 0.15 to 0.22.

With these data, the annual sediment yield for each subwatershed was calculated using Equation 1 and subwatershed land use data (Exhibit 25). The results are presented below.

Table 28

ANNUAL SEDIMENT YIELD FOR STUDY AREA SUBWATERSHEDS

Subwatershed	Load (t/yr)	Area (ac)	Areal Sediment Loading (t/ac/y)
Clear Creek (N)	603	1,871	0.32
Clear Creek	3,380	10,830	0.31
Goshen Creek	1,864	5,172	0.36
Harshman Creek	3,086	8,657	0.36
Jordon Creek	1,770	5,624	0.31
Mitchell Ditch	1,477	3,404	0.43
Miller Creek (N)	1,581	4,515	0.35
Miller Creek	2,363	6,496	0.36
Mud Creek	1,773	4,638	0.38
Total	17,897	51,207	

4.2.2 Phosphorus Loading

Phosphorus loadings to the Mississinewa River were also computed for each of the nine subwatersheds included the study area. The EPA's Simple Method for Watershed Particulate Phosphorus was used. This method calculates phosphorus loadings based on the sediment yield, phosphorus concentration in the soil, and the nutrient enrichment ratio (EPA, 1985). The watershed phosphorus yield due to surface erosion is:

$$W = 0.001 \, s_d \sum_k C s_k X_k A_k \qquad \text{Equation (5)}$$

where

W = particulate phosphorus load in runoff (kg/ha)

Cs_k = concentration of phosphorus in eroded soil (sediment) (mg/kg)

 $X_k =$ soil loss (tons/ha) from source k

The concentration of chemical in eroded soil, Cs, is computed using the following relationship:

$$Cs = en Ci$$

Equation (6)

where

en = nutrient enrichment ratio

Ci = nutrient concentration in in situ soil (mg/kg)

Concentrations of phosphorus in the *in situ* soil were not available from the STATSGO database or the Randolph County Soil Survey. We estimated phosphorus concentration from a general map (EPA, 1985). East central Indiana has a range of percent P_2O_5 as phosphorus of between 0.1 and 0.19 percent. We opted to use an intermediate value of 0.15%, or 660 mg/kg as P.

A nutrient enrichment ratio is a measure of the degree of erosion that occurs during a storm. Since an annual phosphorus load is desired, an enrichment ratio of 2.0 is suggested by EPA (1985). Therefore, the corresponding Cs value is 1,320 mg/kg.

The Cs value is assumed to be the same for all source areas and land types, therefore Equation 5 becomes:

$$W = 1.32 \, s_d \sum_k X_k A_k \qquad \text{Equation (7)}$$

Table 29 contains the results of these calculations for each subwatershed in the study area.

Table 29

ANNUAL PHOSPHORUS LOADINGS

Subwatershed	Annual P Load (kg)	Area (ac)	Areal P Loading (kg/ac/y)
Clear Creek (N)	796	1,870	0.43
Clear Creek	4,462	10,828	0.41
Goshen Creek	2,461	5,173	0.48
Harshman Creek	4,073	8,657	0.47
Jordon Creek	2,336	5,624	0.42
Mitchell Ditch	1,949	3,403	0.57
Miller Creek (N)	2,087	2,087 4,514	
Miller Creek	3,120	6,495	0.48
Mud Creek	2,340	4,638	0.50
Total	23,624	51,202	-

5.0 WATERSHED MANAGEMENT PLAN

This chapter summarizes our knowledge about each subwatershed, contrasts their overall health and pollution sources, and lays the foundation for a watershed management plan for each.

5.1 BIOTIC AND ABIOTIC RELATIONSHIPS

For many years, researchers (e.g. Omernik 1976) have known that land use and stream nutrient concentrations were related. Biotic indictors have also been shown to correlate with land use, physical habitat or water quality. We subjected the biotic and abiotic data generated in this study to statistical analysis to determine if these relationships held locally, and, to aid in the determination of priorities for pollution reduction investments. Correlation coefficients were calculated for each of the major soil and land use types as a function of biotic and abiotic data. Correlation coefficients are an estimate for the presence or absence of a linear relationship between the variables. A high absolute correlation means that a land use is more likely to affect the biotic or abiotic variable. The effect may be positive or negative. We caution readers against rigorous use of these correlations, however, due to the small sample size. With only six (for subwatersheds without sampling stations) or nine data points (subwatersheds with sampling data) for each correlation analysis, correlation may be random, that is, a product of chance and coincidence. For a correlation coefficient to be significant with six data points (i.e. four degrees of freedom), the absolute value of that correlation coefficient must exceed 0.81 for it to be considered significant at or beyond the 0.05 level.

Table 30 presents correlation coefficients for water quality, benthic and physical habitat variables versus pooled land use types. Biotic data came from Table 23; the ratio of scrapers to filterers was inverted to obtain real numbers for inclusion in the analysis. Five correlations are significant at the 5% level. The ratio of filterers to scrapers was positively correlated to two watershed land use types: urban and wetland. The ratio of filterers to scrapers reflects the riffle/run community foodbase. It is indicative of a habitat with excess periphyton and the availability of suspended fine particulate organic material associated with organic enrichment when filterers are more dominant than scrapers. Additionally the total number of benthic organisms collected was positively correlated to water surface area.

Perhaps the most expected correlations involved two land use types and the QHEI score. QHEI was positively correlated with forested land and negatively correlated with agricultural land. Habitat quality is healthier in forested areas and considerably less healthy in agricultural areas.

Exhibit 26 is a correlation matrix for the habitat and biological data. The subwatershed estimates of phosphorus and sediment loadings were not significantly correlated with any factor, including the substrate metrics in the QHEI. Again, we caution the reader against to interpreting these as cause and effect relationships; the sample size is small and there is a strong likelihood of random correlation.

Table 30

LAND USE CORRELATION COEFFICIENTS

Habitat Variable	Urban	Agriculture	Forest	Wetland	Water
Conductivity	0.40	0.11	-0.28	0.04	0.33
E. coli	0.01	-0.56	0.65	0.17	0.71
Nitrogen, Total Kjeldahl	-0.47	0.61	-0.51	-0.43	-0.37
Nitrogen, Nitrate+Nitrate	0.02	0.36	-0.49	-0.08	0.11
РН	-0.39	0.78	-0.71	-0.39	-0.42
Total Phosphorus	-0.12	0.58	-0.51	-0.35	-0.07
Dissolved Phosphorus	0.38	0.27	-0.49	0.24	-0.46
Turbidity	0.70	-0.29	-0.01	0.75	0.14
Substrate Score	0.16	0.18	-0.31	-0.18	-0.21
QHEI Score	-0.03	-0.86	0.82	-0.01	0.37
Taxa Richness	-0.64	0.67	-0.50	-0.66	-0.09
Family Biotic Index	-0.10	-0.23	0.44	0.13	-0.22
* Ratio of Filterers to Scrapers	0.94	-0.48	0.14	0.92	0.20
Ratio of EPT/Chironomidae	0.64	0.04	-0.36	0.56	0.10
% Contribution of Dominate Family	0.51	-0.14	-0.07	0.18	0.28
EPT Index	-0.24	0.75	-0.75	-0.29	-0.34
Ratio of Shredders/Nonshredders	-0.33	-0.29	0.30	-0.58	0.40
Total Number of Benthic Organisms Collected	0.05	-0.09	0.03	-0.12	0.94
Areal Sediment Loading	0.04	0.59	-0.55	0.34	0.17
Areal Phosphorus Loading	0.07	0.56	-0.51	0.38	0.15

Table 30

LAND USE CORRELATION COEFFICIENTS

Habitat Variable	Urban	Agriculture	Forest	Wetland	Water
Silt Cover	0.05	0.69	-0.66	-0.12	-0.36
Embeddedness	0.79	0.19	-0.46	0.61	-0.09

^{*} An inverse of the scraper/filtering collector ratio was utilized to avoid dividing by 0.

5.2 SUBBASIN COMPARISONS

Predictive modeling provided estimates of the relative significance of nonpoint source loadings to the nine Mississinewa tributaries in the study area. Physical, chemical and biological field studies provided information on relative environmental health of six of these tributaries. To rank the subwatersheds on the basis of relative need for nonpoint source controls, we selected four of these indicators: areal sediment and phosphorus (P) loading rates, Family Biotic Index (FBI) and Qualitative Habitat Evaluation Index (QHEI). The loadings estimates are part of the rankings as they directly reflect nonpoint source pollution. FBI and QHEI are also included as they are based on multi-metric indices that, cumulatively, are measurements of ecosystem integrity and health. Table 31 reiterates these four indicators. For each indicator, we ranked the subwatersheds, from one to nine, with the lowest rank reflecting the most severe loading or poorest health for that indicator.

RANKING OF SUBWATERSHEDS
ACCORDING TO FOUR KEY ENVIRONMENTAL INDICATORS

Table 31

Subwatershed	Areal Sedi Loadir		Areal P Loading FBI		BI	QHEI		
	Tons/ac/yr	Rank	kg/ac/yr	Rank	Score	Rank	Score	Rank
Mitchell Ditch	0.434	1	0.573	1				
Jordon Creek	0.315	8	0.415	8	6.463	1	60.5	3
Mud Creek	0.382	2	0.504	2	5.641	2	66.5	4
Miller Creek	0.364	3	0.480	3	5.625	3	55.5	1
Miller Creek N	0.350	6	0.462	6				
Clear Creek	0.312	9	0.412	9	4.648	4	74.0	6
Clear Creek N	0.322	7	0.426	7				
Goshen Creek	0.360	4	0.476	4	4.013	5	67.5	4
Harshman Creek	0.356	5	0.470	5	3.744	6	68.0	5

Based upon these rankings, we sorted the subwatersheds into three groups reflecting their relative need for nonpoint source pollution controls (Exhibit 27, Table 32). Mitchell Ditch, Mud Creek and Miller Creek are most stressed and have the greatest areal loadings of sediment and phosphorus. The upper Mississinewa River would benefit from investments in these three subwatersheds.

Table 32

SUBWATERSHED PRIORITIES FOR
NONPOINT SOURCE CONTROL INVESTMENT

Priority	Subwatersheds
	Mitchell Ditch
High	Mud Creek
	Miller Creek
	Jordon Creek
Moderate	Goshen Creek
	Miller Creek N
	Clear Creek
Low	Clear Creek N
	Harshman Creek

5.3 AGRICULTURAL BEST MANAGEMENT PRACTICES

Best management practices, or BMPs, are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. The study area watershed is largely agricultural. There is a broad range of BMPs for agricultural lands. Appendix E discusses many of these. For the lands in the study area where corn and soybean production is the dominant use, some of the most effective BMPs include conservation tillage, conservation buffers and nutrient management.

5.3.1 Conservation Tillage

Conservation tillage, or crop residue management, involves leaving at least 30% of the ground covered with plant residue after planting. Varieties of conservation tillage include no-till/strip-till, ridge-till and mulch-till. Conservation tillage is widely practiced throughout Indiana and the Midwest. Conservation tillage improves water quality by reducing soil erosion and transport. It also improves soil quality by increase organic content, moisture and nutrient retention capacity, and tilth.

Table 33 contains data on tillage practices for various crops for three years. These data were exported from the TRANSECT Program administered by Purdue University, which was provided to Harza upon request. These data are specific to Randolph County rather than the Mississinewa River watershed, but likely are a reasonable representation of regional trends in adopting conservation tillage. Total acreage in conservation tillage has increased dramatically in the last decade, from 11,000 acres in 1989 to over 100,000 acres in 1999, over half of the tilled land. This is an excellent tribute to the SWCD.

The previous year's crop essentially controls the amount of tillage that can be performed while retaining 30% residue cover in the field. This may require crop rotation, as corn produces significant residue that can be left on the field, but soybeans do not.

All Indiana counties have extension agents available to provide technical assistance for implementing conservation tillage programs. In a 1997 nationwide survey of growers, the Natural Resource Conservation Service (NRCS) found that operation costs were rarely an impediment to implementing conservation tillage practices (cited in NRCS 1999). More common reasons stated in that survey were the expense of equipment changes and weed problems. As illustrated in Table 34, operating costs may be less under no-till systems than conventional tillage system. Costs for procuring the equipment however can be challenging for some operators.

Table 33

PRESENT CROP ACREAGE IN RANDOLPH COUNTY BY TILLAGE SYSTEM
(Source: TRANSECT, Purdue University)

Tillage	Corn	Soybeans	Small grains	Forage	Idle	Other	Unknown	Total
	1989							1.
Conventional	54,041	92,214	-	-	429	-	-	146,684
Mulch-till	-	429	-	-	-	-	-	429
No-till	3,860	4,718	-	-	-	-	-	8,578
Ridge-till	1,287	858	-	-	-	-	-	2,145
Other	-	-	-	-	-	-	-	-
N/A	-	-	-	9,436	-	-	-	9,436
Unknown	-	-	23,161	-	10,723	858	-	34,741
Total	59,188	98,218	23,161	9,436	11,151	858	-	202,012
1	1994							
Conventional	45,912	40,486	10,434	-	-	417	-	97,249
Mulch-till	417	2,922	417	-	-	-	417	4,174
No-till	20,869	58,016	7,095	-	-	-	-	85,980
Ridge-till	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-
N/A	-	417	-	7,513	2,504	7,930	-	18,365
Unknown	-	-	-	-	-	-	835	835
Total	67,198	101,841	17,947	7,513	2,504	8,348	1,252	206,603
			19	99				
Conventional	55,799	27,489	2,462	-	410	821	821	87,801
Mulch-till	-	821	821	-	-	-	-	1,641
No-till	18,463	78,775	3,693	-	-	-	-	100,930
Ridge-till	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-
N/A	-	-	-	5,744	2,462	-	-	8,206
Unknown	-	-	1,641	-	410	-	-	2,051
Total	74,262	107,085	8,616	5,744	3,282	821	821	200,630

Table 34

OPERATING COSTS (\$/acre) FOR CONVENTIONAL TILLAGE VERSUS NO-TILL

(adapted from NRCS 1999)

Crops	Conventional Tillage	No-till System	Increase/decrease
	Corn		
Operating/machinery	17	5	-12
Material	100	95	-5
Other	5	5	0
Total	122	105	-17
	Soybear	ıs	
Operating/machinery	14	6	-8
Material	55	83	28
Other	3	4	1
Total	72	93	21
	Wheat	1	
Operating/machinery	12	6	-6
Material	38	49	11
Other	3	3	0
Total	53	58	5

5.3.2 Conservation Buffers

Conservation buffer strips of vegetation can, if properly planned and maintained, greatly reduce the runoff of soil and associated pollutants to nearby receiving waters. There are many practices that can be broadly grouped together as conservation buffers:

- Riparian buffers along streams
- Contour grass strips
- · Field border buffers
- Filter strips
- · Grassed swales and waterways
- Hedges or living snow fences

- Wetlands
- Other strategically planted vegetation that can intercept pollution or reduce wind or water erosion

Besides reducing sediment, nutrients and pesticides in runoff water, conservation buffers can greatly increase wildlife habitat. Filter strips should not be less than 20 feet, and protection of some resources may require much wider vegetation strips. Upgradient land slopes greater than 6% should have wider strips, possibly as wide as 130 feet. Floodplain riparian buffers having higher flows and longer duration flooding may need to be upwards of 200-feet wide.

The USDA's Conservation Reserve Program (CRP) is an excellent opportunity for establishing conservation buffers. Costs for installation of conservation buffers ranges widely, as expected given the broad variety of buffer types. The CRP shares in the cost of installation of conservation buffers and provides for long-term contracts for the setting aside of eligible lands.

5.3.3 Nutrient Management

A crop nutrient management plan can increase the efficiency of crop fertilizer use while reducing nutrient losses to streams and lakes. Nutrient management reduces both production risk and environmental risk, and can increase agricultural profitability. Classically, nutrient management plans contain the following ten components:

- 1. Field Map. Acreage, soils, water bodies and other sensitive habitats.
- 2. Soil Test. Determining soil nutrient status.
- 3. Crop Rotation. Sequencing of crops affects fertilizer needs.
- 4. Estimated Crop Yield.
- Sources and Forms of Nutrients. Manure/sludge fertility analysis and understanding of inorganic fertilizers.
- 6. Sensitive Environmental/Social Areas.
- 7. Recommended Rates of N, P & K.
- 8. Timing of Applications.
- 9. Methods of Applications.
- 10. Annual Review and Update.

Again, all Indiana counties have extension agents available to provide technical assistance for developing nutrient management plans. Recent NRCS guides have estimated consulting for preparation of nutrient management plans at \$5/acre (NRCS 1999). Based upon this unit rate and adjusting for inflation, plan development for the nine subwatersheds will cost approximately \$240,000 (Table 35).

Table 35
ESTIMATED COSTS FOR DEVELOPMENT
OF NUTRIENT MANAGEMENT PLANS

Subwatershed	Cost
Clear Creek (N)	\$ 8,000
Clear Creek	\$ 50,000
Goshen Creek	\$ 24,000
Harshman Creek	\$ 41,000
Jordon Creek	\$ 26,000
Mitchell Ditch	\$ 16,000
Miller Creek (N)	\$ 21,000
Miller Creek	\$ 31,000
Mud Creek	\$ 22,000
Total	\$ 239,000

5.4 CONSTRUCTED WETLANDS

While BMPs are excellent source controls, they may not be sufficient to bring pollution loadings to levels where aquatic life is not stressed. Over the last two decades, interest has increased for the use of constructed wetlands for treatment of nonpoint source pollution. Constructed wetlands are designed specifically for water treatment and serve in a similar capacity as other water quality BMPs, to minimize pollution prior to its entry into streams, lakes and other receiving waters.

Among the most important treatment processes in wetlands are the purely physical processes of sedimentation. Sedimentation accounts for the relatively high removal rates for suspended solids, the particulate fraction of organic matter and sediment-bound nutrients and metals. Pathogens show good removal rates in constructed wetlands via

sedimentation, natural die-off, and UV degradation. Dissolved constituents such as soluble organic matter, ammonia and ortho-phosphorus tend to have lower removal rates. Soluble organic matter is largely degraded aerobically by bacteria and periphyton. Ammonia is removed through microbial nitrification-denitrification, plant uptake, and volatilization. Nitrate is removed through denitrification and plant uptake. Phosphorus is removed mainly through soil sorption, plant assimilation and burial. Phosphorus removal rates are variable and typically trail behind those of nitrogen.

General ranges of removal for various pollutants by constructed wetlands are given below.

Table 36

CONSTRUCTED WETLAND POLLUTANT REMOVAL EFFICIENCY

(Source: Schueler, 1987, Schueler et al. 1992)

Pollutant	Efficiency
Bacteria	High
Oil and Grease	Very high
BOD	Moderate
Trace metals (sediment-bound)	High
Sediment	High
Total Phosphorus	High
Total Nitrogen	Moderate

Development of constructed wetlands for treatment remains an emerging technology and design criteria continue to evolve. General design considerations include the requirement to reduce runoff velocities and provide opportunities for sedimentation. Generally designers attempt to maximize the hydraulic residence time and the distribution of flow over the treatment area.

Constructed wetlands can be a very effective part of a BMP system. Given the high nutrient concentrations in the study area's streams, constructed wetlands should be considered for development in high priority subwatersheds: Miller Creek, Mitchell Ditch and Mud Creek. Costs for development of wetlands can vary with size, site topography and other factors. Wetlands are generally sized according to treatment needs for the

volume and quality of inflows. Treatment wetland unit costs can range from \$5,000 per acre to upwards of \$25,000 per acre. Wetland construction requires permits from the US Army Corps of Engineers, the IDNR, Indiana Department of Environmental Management (IDEM) and, if the site in on a regulated drain, the approval of the County Drainage Board.

5.5 FUNDING SOURCES

There are several agencies providing funding for projects which address water quality, erosion control, storm water, nonpoint source pollution, wetlands, and wildlife. Funding agencies include the branches of the United States Department of Agriculture (Natural Resources Conservation Service (NRCS) and the United States Forest Service), branches of the United States Department of Interior (Fish and Wildlife Service and the Bureau of Reclamation), the United States Environmental Protection Agency, and the United States Corps of Engineers. Many of these funding agencies provide money to the states, which in turn, fund such programs as IDEM's Section 319 Nonpoint Source (NPS) Program. Other programs are financed at the state level, such as the LARE Program.

These programs include both grants and loans. In general, most of the programs require cost share requirements specifying non-federal contributions from 5 to 75%. There is currently policy and programmatic revisions underway at IDEM that will make non-point source control project eligible for financing by the State Revolving Loan Fund. This is an important new facet of the SRF and presents a significant financial resource for watershed managers in the state.

The SRF was created by the Clean Water Act Amendments in 1987 and has most commonly been used to finance municipal wastewater collection and treatment projects. Indiana's SRF Program offers low-interest loans to qualified communities for the planning, design, and construction of publicly-owned wastewater facilities. The SRF currently provides the lowest cost financing for these wastewater projects. The program is jointly managed by the IDEM and the State Budget Agency (SBA). IDEM is SRF Program administrator and the SBA is financial manager. Currently, IDEM is revising its policy and, in a year or so, nonpoint source projects will be eligible for SRF financing. Together, the EPA and the State of Indiana have provided over \$342 million to the SRF through 1998. Although future funding is uncertain, the program will be self-sustaining through the repayment of the loans. Communities eligible to apply for SRF loans are

political subdivisions including incorporated cities and towns, counties, townships, municipal corporations, conservancy districts, sanitary districts, and regional water, sewer and waste districts.

The 1995 session of the General Assembly passed Senate Bill 66 to provide a three-tiered interest rate policy for the SRF program. The new policy allows the SRF program to be more affordable to communities, especially Indiana's poorer communities. The interest rate available to a community is based on the median household income (MHI) of the service area. In addition, a community may be eligible for 0% interest for up to two years depending upon the communities' MHI.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This diagnostic study has examined the physical, biological and chemical effects of nonpoint source pollution on tributary streams in the heavily agricultural area of the upper Mississinewa River watershed. There is some evidence to suggest that water quality is improving in the Mississinewa River. We attribute this to improvements in point source controls in Union City, and, possibly, nonpoint source controls throughout the watershed.

6.1 SUBBASIN HEALTH AND PRIORITIES FOR INVESTMENT

We monitored instream habitat, macroinvertebrate community health, and water quality in six of nine tributaries in the study area. Predictive models of nonpoint source loadings were developed for all nine. We used these data to rank these streams according to the level of ecological stress each was being subjected to. Four indicators were selected to rank the subwatersheds on the basis of relative need for nonpoint source controls. These indicators were: areal sediment and phosphorus (P) loading rates, Family Biotic Index (FBI) and Qualitative Habitat Evaluation Index (QHEI). We then sorted the subwatersheds into three groups reflecting their relative need for nonpoint source pollution controls. Mitchell Ditch, Mud Creek and Miller Creek are most stressed and have the greatest areal loadings of sediment and phosphorus. The upper Mississinewa River would benefit from investments in these three subwatersheds.

6.2 BEST MANAGEMENT PRACTICES (BMPs)

The study area watershed is heavily agricultural. There is a broad range of BMPs for agricultural lands. Some of the most effective BMPs include conservation tillage, conservation buffers and nutrient management. Conservation tillage is being widely adopted by growers. In Randolph County, over half of farmland was under some type of conservation tillage practice in 1999, a dramatic increase since 1989. This is a tribute to the extension service officers. Conservation tillage should continue to be a focus of their efforts.

Stream nutrient concentrations remain high in the study area. Filamentous algae and periphyton levels on stream substrates were very abundant. This manifests itself in large diurnal fluctuations in dissolved oxygen and stresses aquatic life. Conservation tillage,

buffer systems, and, especially nutrient management planning will mitigate these conditions.

6.3 INSTITUTIONS

In Appendix A, a broad range of institutional initiatives is outlined for furthering watershed education and effecting positive change. Our principal institutional recommendation at this time is the galvanization of a stakeholder group to steer subsequent phases of watershed management, including developing nutrient management plans and an engineering feasibility study for constructed wetlands in high-priority subwatersheds.

6.4 PROJECTS

Constructed wetlands can be a very effective part of a BMP system. Given the high nutrient concentrations in the study area streams, constructed wetlands should be considered for development in high priority subwatersheds: Miller Creek, Mitchell Ditch and Mud Creek. More detailed sitings and layouts for wetlands will be evaluated in a feasibility-level investigation. We recommend that the SWCD seek the involvement of local landowners in these three drainages. We recommend their involvement initially be as advisors to a LARE-sponsored engineering feasibility study for constructed wetland in Miller Creek, Mitchell Ditch and Mud Creek subwatersheds. As their interest and understanding of wetland systems and their benefits increases, one or more could possibly serve as co-sponsor for construction of the wetland.

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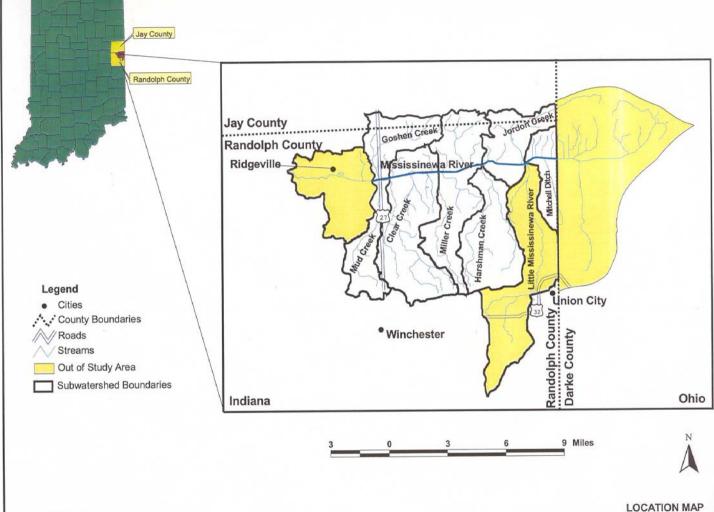
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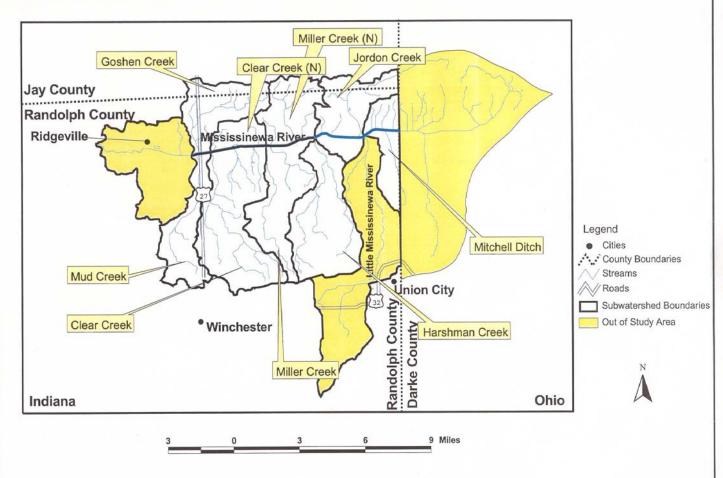
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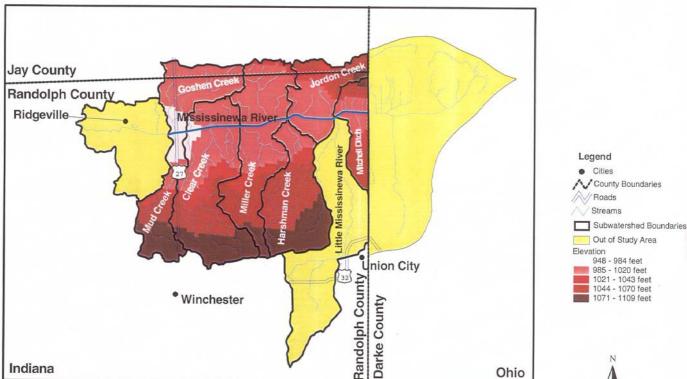
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EXHIBITS

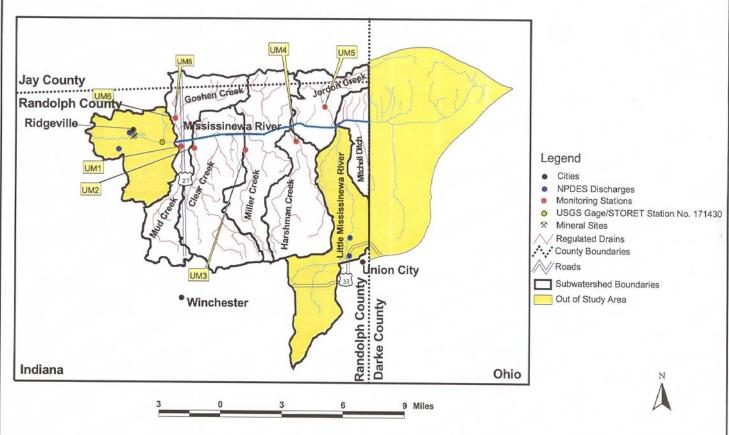


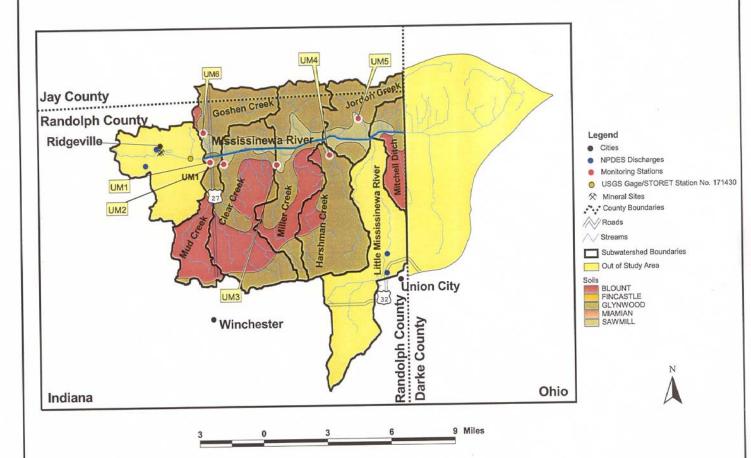


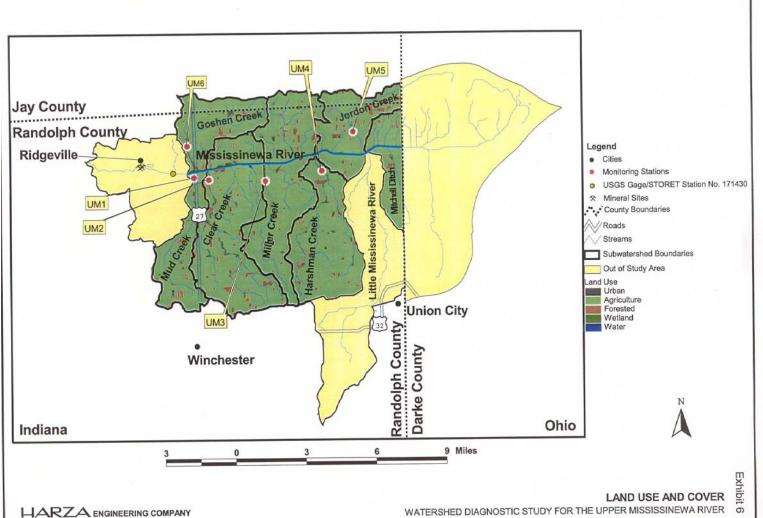




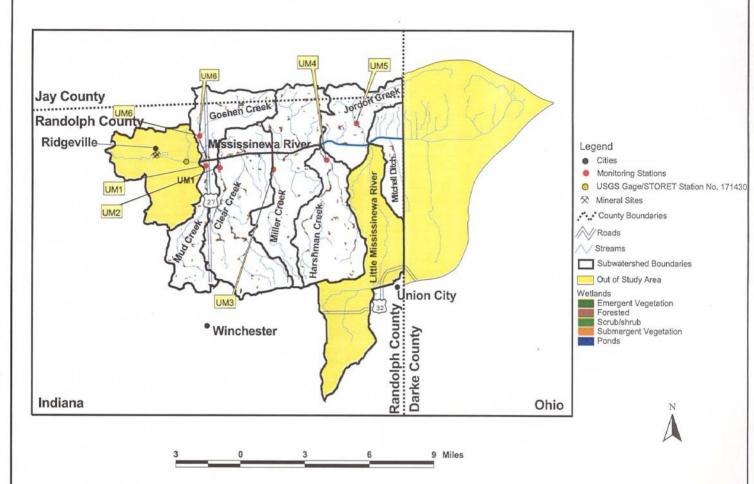








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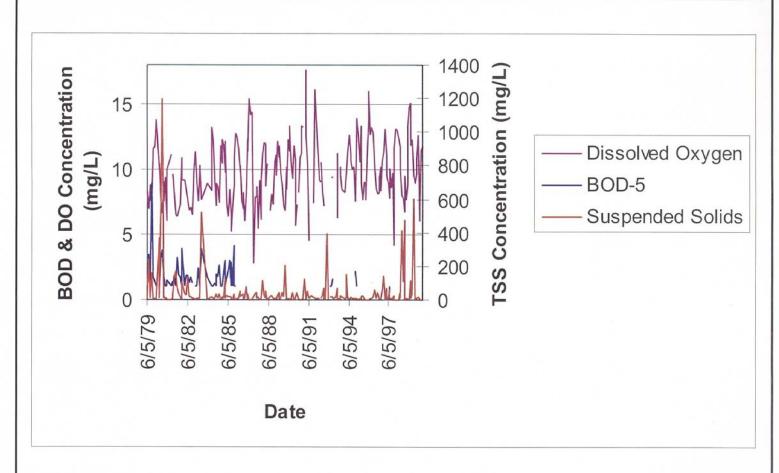
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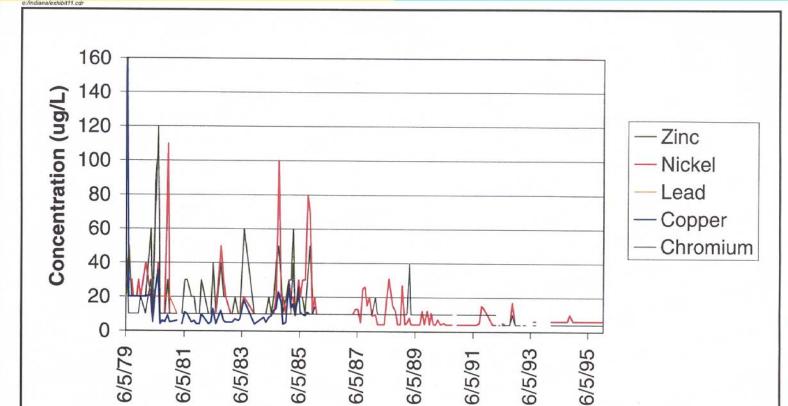
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RANDOLPH COUNTY SOIL & WATER CONSERVATION DISTRICT

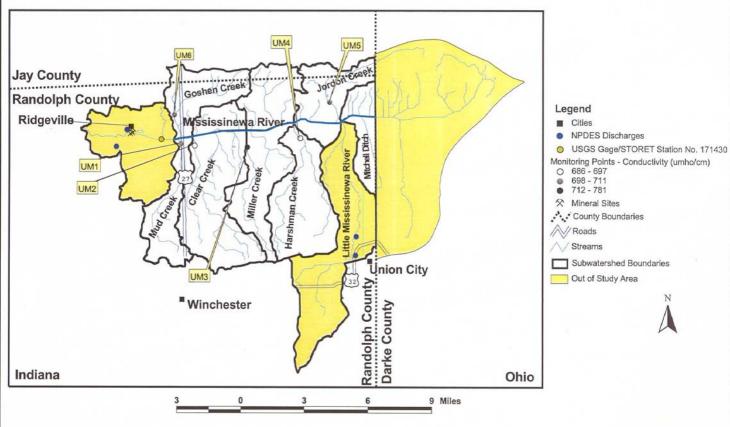


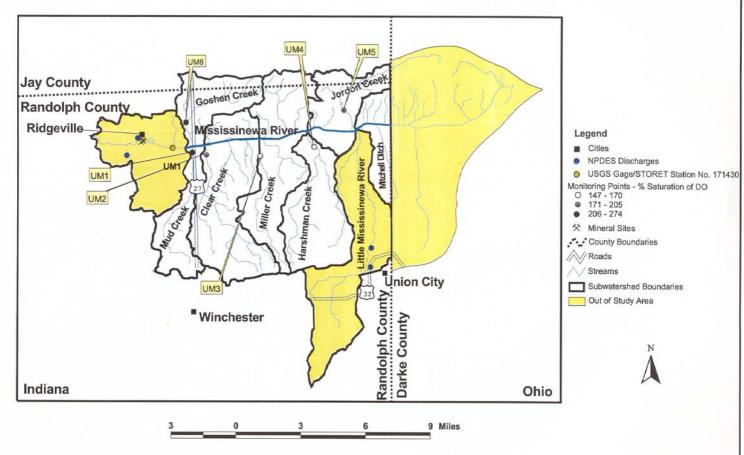
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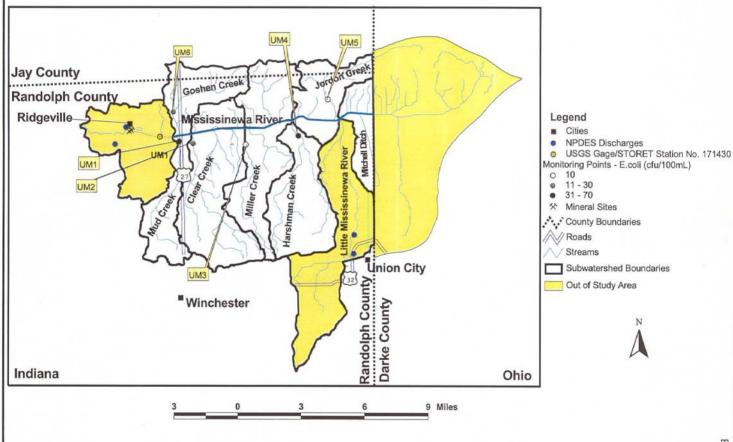
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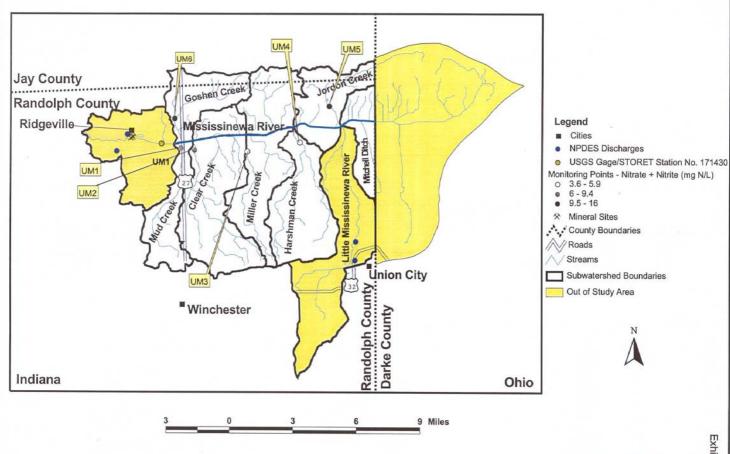
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RANDOLPH COUNTY SOIL & WATER CONSERVATION DISTRICT

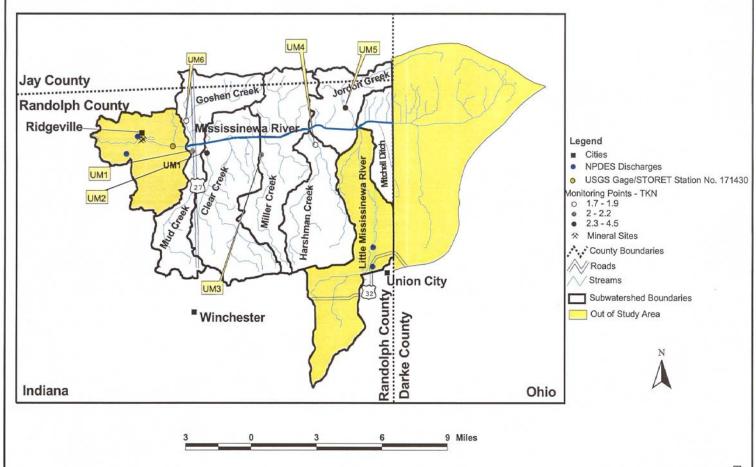
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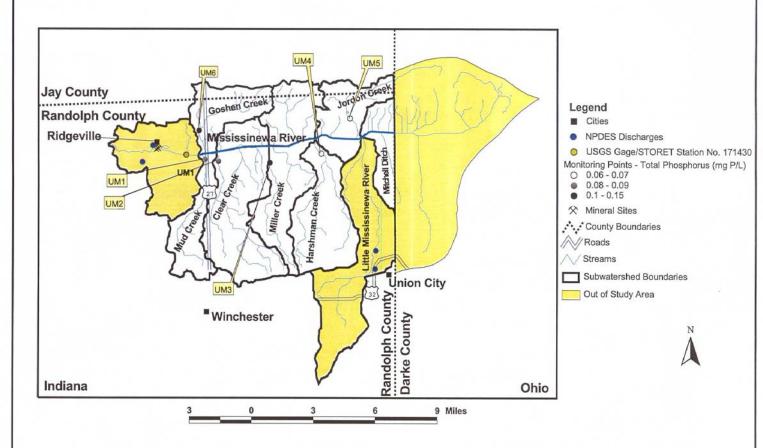


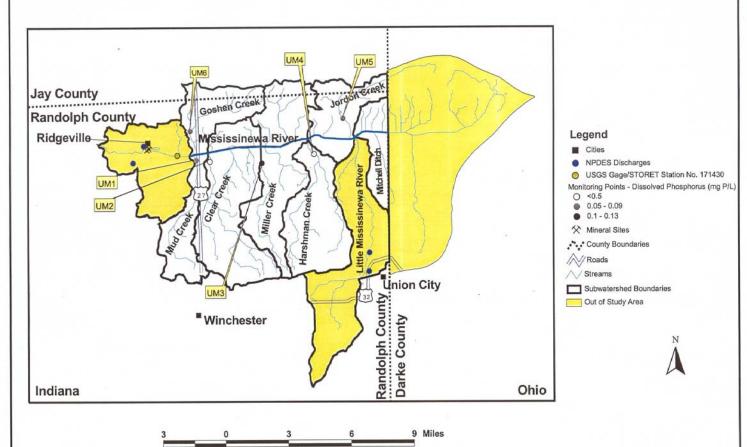


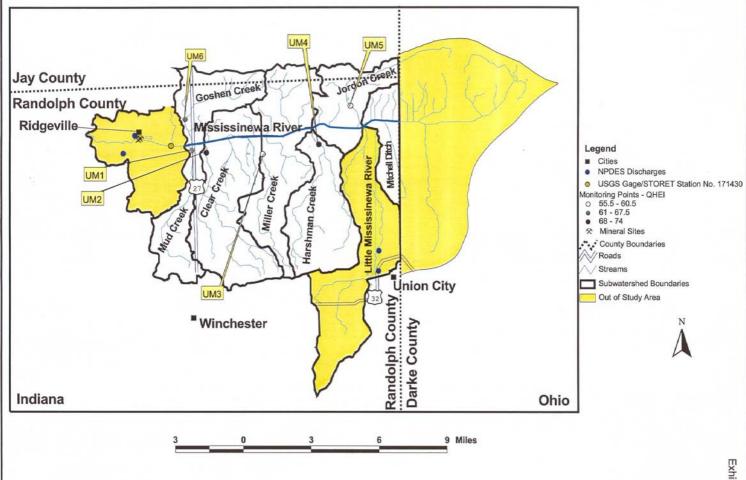


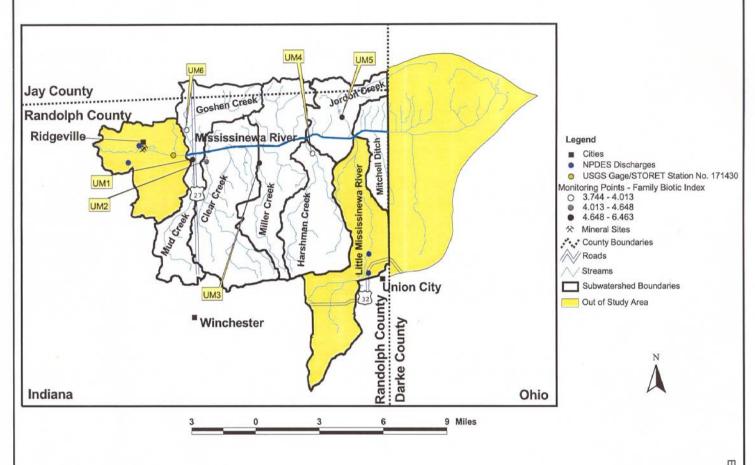


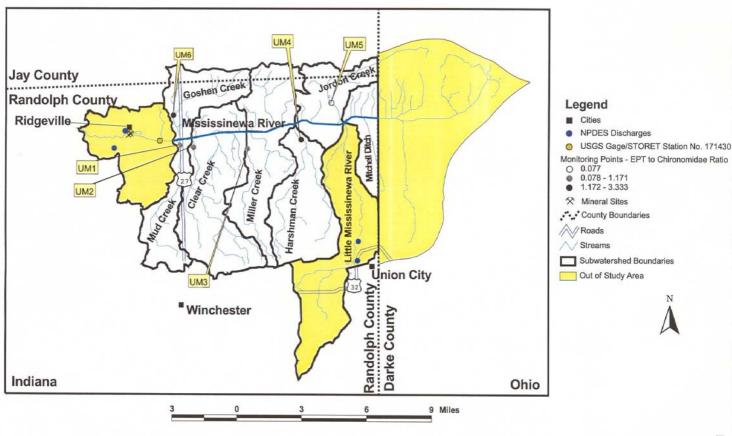


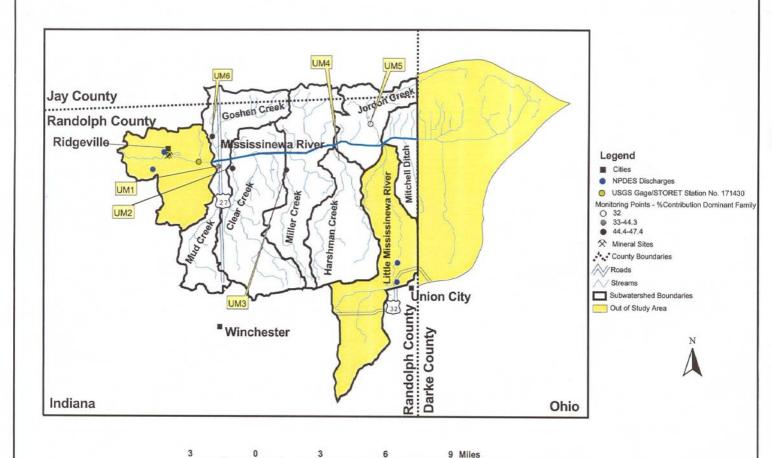


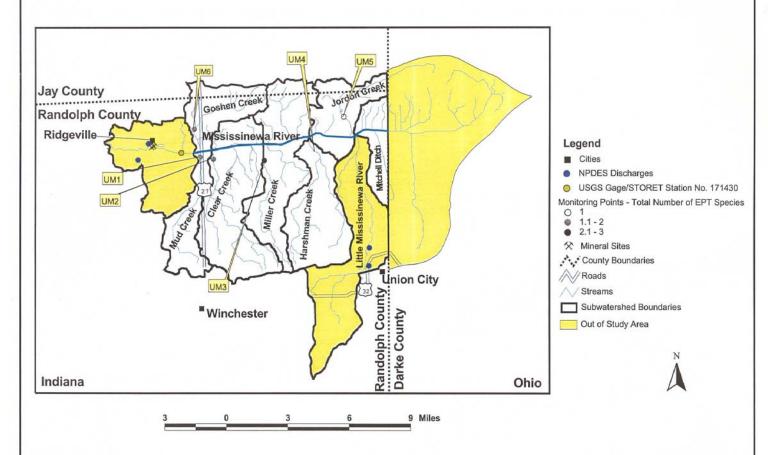


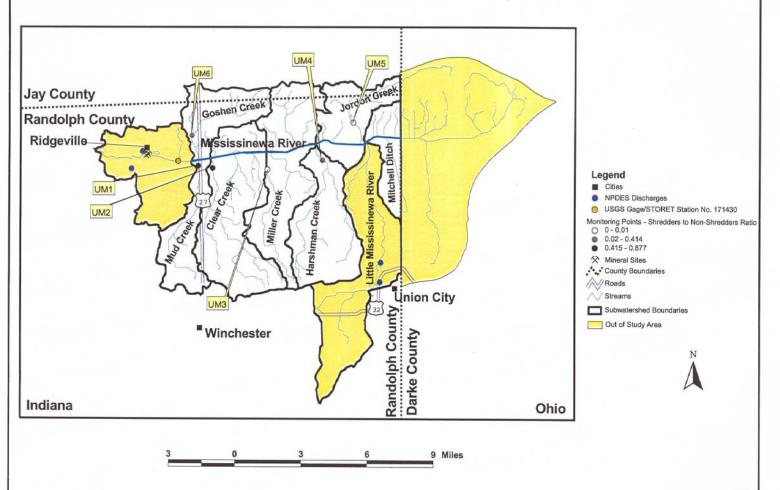












Soils	Land Use	Clear Creek (N)	Clear Creek	Goshen Creek	Harshman Creek	Jordan Creek	Adjacent Jordan Creek	Miller Creek (N)	Miller Creek	Mud Creek
BLOUNT	Other Non-vegetated	0	0	0	0	0	0	0	0	0
	Urban High Density	0	0	0	0	0	0	0	10	0
	Urban Low Density	0	0	0	0	0	0	0	13	0
	Agriculture Row Crop	0	5331	115	1063	0	1614	0	2911	2781
	Agriculture Pasture/Grassland	0	449	56	74	0	23	0	200	462
	Shrubland	0	8	3	0	0	9	0	7	14
	Woodland	0	8	0	0	0	0	0	1	10
	Forest Deciduous	0	250	5	47	0	42	0	29	155
	Forest Evergreen	0	5	0	0	0	0	0	0	4
	Forest Mixed	0	0	0	0	0	0	0	0	0
	Wetland Forest	0	75	0	18	0	5	0	3	29
	Wetland Woodland	0	0	0	0	0	0	0	0	0
	Wetland Shrubland	0	0	0	3	0	0	0	4	0
	Wetland Herbaceous	0	22	0	0	0	0	0	6	0
	Wetland Sparsely Vegetated	0	- 0	0	0	0	0	0	0	0
	Water	0	0	0	0	0	0	0	0	9
GLYNWOOD	Other Non-vegetated	0	0	0	0	0	0	0	0	0
	Urban High Density	0	0	0	0	3	0	0	0	0
	Urban Low Density	0	0	0	0	3	0	0	13	17
	Agriculture Row Crop	841	3510	3633	6556	3180	1012	2632	2460	883
	Agriculture Pasture/Grassland	118	454	564	492	660	153	583	287	177
	Shrubland	6	17	9	10	13	6	16	12	0
	Woodland	0	6	3	0	0	0	0	0	0
	Forest Deciduous	41	291	194	167	382	69	163	58	50
	Forest Evergreen	0	0	0	0	0	0	0	0	0
	Forest Mixed	0	0	0	0	0	0	0	0	0
	Wetland Forest	26	116	83	113	14	7	49	30	47
	Wetland Woodland	0	0	0	0	0	0	0	0	0
	Wetland Shrubland	0	4	3	0	0	0	0	5	0
	Wetland Herbaceous	0	6	0	3	4	8	0	0	0
	Wetland Sparsely Vegetated	0	4	0	0	0	0	0	0	0
	Water	0	0	5	0	0	0	0	0	0

Sheet 1 of 2

Sheet 1 of 2
SUBWATERSHED SOILS AND LANDUSE (ACRES)
UPPER MISSISSINEWA RIVER WATERSHED DIAGNOSTIC ANALYSIS
RANDOLPH COUNTY SOIL & WATER CONSERVATION DISTRICT
Winchester, Indiana

Soils	Land Use	Clear Creek (N)	Clear Creek	Goshen Creek	Harshman Creek	Jordan Creek	Adjacent Jordan Creek	Miller Creek (N)	Miller Creek	Mud Creek
MIAMIAN	Other Non-vegetated	0	0	0	0	0	0	0	0	0
	Urban High Density	0	0	0	0	0	0	0	0	0
	Urban Low Density	0	0	0	0	0	0	0	0	0
	Agriculture Row Crop	0	4	0	0	0	0	0	0	0
	Agriculture Pasture/Grassland	0	2	0	0	0	0	0	0	0
	Shrubland	0	0	0	0	0	0	0	0	0
	Woodland	0	0	0	0	0	0	0	0	0
	Forest Deciduous	0	0	0	0	0	0	0	0	0
	Forest Evergreen	0	0	0	0	0	0	0	0	0
	Forest Mixed	0	0	0	0	0	0	0	0	0
	Wetland Forest	0	0	0	0	0	0	0	0	0
	Wetland Woodland	0	0	0	0	0	0	0	0	0
	Wetland Shrubland	0	0	0	0	0	0	0	0	0
	Wetland Herbaceous	0	0	0	0	0	0	0	0	0
	Wetland Sparsely Vegetated	0	0	0	0	0	0	0	0	0
The sales of the Array of the sales	Water	0	0	0	0	0	0	0	0	0
SAWMILL	Other Non-vegetated	0	0	0	0	0	0	0	0	0
th.	Urban High Density	6	0	0	0	0	0	2	0	0
	Urban Low Density	2	0	98	0	0	0	3	0	0
	Agriculture Row Crop	607	181	279	93	1207	427	795	347	0
	Agriculture Pasture/Grassland	113	22	58	0	70	2	148	60	0
	Shrubland	7	0	5	0	11	0	7	1	0
	Woodland	0	0	0	0	0	0	,	0	0
	Forest Deciduous	99	21	33	6	10	17	54	12	0
	Forest Evergreen	0	0	0	0	0	0	0	0	0
	Forest Mixed	0	0	0	0	0	0	0	0	0
	Wetland Forest	4	31	27	12	66	9	43	23	0
	Wetland Woodland	0	0	0	0	0	0	0	0	0
	Wetland Shrubland	0	0	0	0	0	0	3	2	0
	Wetland Herbaceous	0	5	0	0	1	0	16	1	0
	Wetland Sparsely Vegetated	0	0	0	0	0	0	0	0	
	Water	0	6	0	0	0	0	0	0	0
TOTAL		1,871	10,830	5,172	8,657	5,624	3,404	4,515	6,496	4,638

Sheet 2 of 2



Sheet 2 of 2

SUBWATERSHED SOILS AND LANDUSE (ACRES)

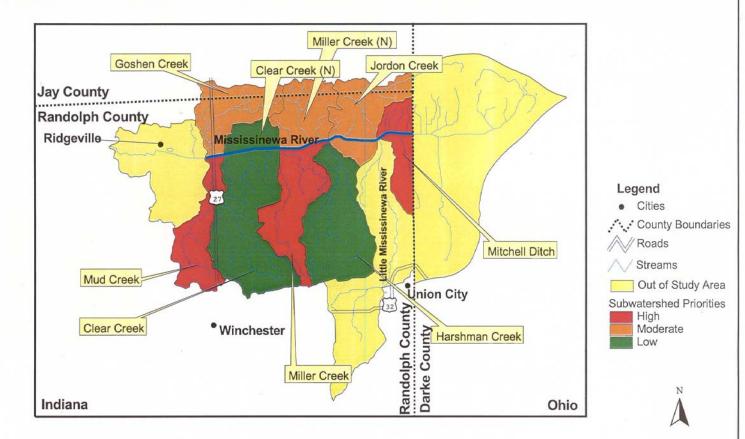
WHITE PER MISSISSINEWA RIVER WATERSHED DIAGNOSTIC ANALYSIS
RANDOLPH COUNTY SOIL & WATER CONSERVATION DISTRICT
Winchester, Indiana



Habitat Measure	Conductivity	E. coli	Kjeldahl N	NO ₃ +NO ₂	pН	Total P	Dissolved Phosphorus	Turbidity	Substrate Score	QHEI Score	Taxa Richness	FBI	Nonscrapers/ Scrapers	EPT/Chiro nomidae	% Dom Family	EPT Index	CPOM	Total Number	Sediment Loading	P Loading	Silt Cover	Embeddedness
E. coli	-0.04	1.00	-0.48	-0.31	-0.58	-0.18	-0.49	-0.07	-0.58	0.40	-0.20	0.38	-0.01	-0.32	-0.06	-0.60	0.12	0.66	0.12	0.16	-0.44	-0.38
Kjeldahl Nitrogen	-0.62	-0.48	1.00	0.80	0.96	-0.25	-0.49	0.15	-0.31	-0.37	0.89	-0.62	-0.36	0.35	-0.74	0.95	-0.14	-0.14	0.19	0.09	-0.12	-0.38
Nitrate+Nitrate N	-0.41	-0.31	0.80	1.00	0.75	-0.43	-0.76	0.56	-0.31	-0.19	0.69	-0.91	0.10	0.75	-0.49	0.84	-0.05	0.22	0.51	0.41	-0.33	-0.16
pH	-0.44	-0.58	0.96	0.75	1.00	-0.03	-0.29	0.09	-0.19	-0.59	0.87	-0.56	-0.36	0.35	-0.61	0.98	-0.27	-0.16	0.32	0.23	0.13	-0.17
Total Phosphorus	0.76	-0.18	-0.25	-0.43	-0.03	1.00	0.70	-0.71	0.59	-0.53	0.00	0.35	-0.44	-0.50	0.58	-0.09	0.03	0.07	0.21	0.25	0.90	0.41
Dissolved Phosphorus	0.76	-0.49	-0.49	-0.76	-0.29	0.70	1.00	-0.30	1.00	-0.56	-0.59	0,74	0.16	-0.25	0.77	-0.32	-0.56	-0.57	-0.52	-0.21	0.87	0.90
Turbidity	-0.32	-0.07	0.15	0.56	0.09	-0.71	-0.30	1.00	-0.33	0.07	-0.16	-0.50	0:84	0.92	-0.20	0.24	-0.38	-0.03	0.31	0.31	-0.47	0.29
Substrate Score	0.75	-0.58	-0.31	-0.31	-0.19	0.59	1.00	-0.33	1.00	-0.01	-0.33	-0.02	0.03	-0.14	0.80	-0.15	0.38	-0.28	-0.23	-0.22	0.58	0.53
QHEI Score	-0.12	0.40	-0.37	-0.19	-0.59	-0.53	-0.56	0.07	-0.01	1.00	-0.37	-0.04	0.18	-0.14	0.11	-0.56	0.70	0.16	-0.57	-0.59	-0.75	-0.46
Taxa Richness	-0.43	-0.20	0.89	0.69	0.87	0.00	-0.59	-0.16	-0.33	-0.37	1.00	-0.52	-0.64	0.07	-0.64	0.82	0.06	0.23	0.33	0.22	-0.05	-0.52
Family Biotic Index	0.14	0.38	-0.62	-0.91	-0.56	0.35	0.74	-0.50	-0.02	-0.04	-0.52	1.00	-0.17	-0.72	0.17	-0.68	-0.27	-0.26	-0.39	-0.28	0.33	0.07
Ratio of Nonscrapers to Scrapers	0.11	-0.01	-0.36	0.10	-0.36	-0.44	0.16	0.84	0.03	0.18	-0.64	-0.17	1.00	0.72	0.30	-0.21	-0.30	-0.09	0.17	0.22	-0.23	0.60
Ratio of EPT to Chironomidae	-0.17	-0.32	0.35	0.75	0.35	-0.50	-0.25	0.92	-0.14	-0.14	0.07	-0.72	0.72	1.00	-0.13	0.50	-0.33	0.00	0.49	0.46	-0.25	0.38
% Contrib of Dom Family	0.95	-0.06	-0.74	-0.49	-0.61	0.58	0.77	-0.20	0.80	0.11	-0.64	0.17	0.30	-0.13	1.00	-0.55	0.32	0.12	0.04	0.09	0.47	0.65
EPT Index	-0.39	-0.60	0.95	0.84	0.98	-0.09	-0.32	0.24	-0.15	-0.56	0.82	-0.68	-0.21	0.50	-0.55	1.00	-0.26	-0.12	0.40	0.31	0.09	-0.07
СРОМ	0.26	0.12	-0.14	-0.05	-0.27	0.03	-0.56	-0.38	0.38	0.70	0.06	-0.27	-0.30	-0.33	0.32	-0.26	1.00	0.38	-0.33	-0.40	-0.31	-0.45
Total Number Collected	0.27	0.66	-0.14	0.22	-0.16	0.07	-0.57	-0.03	-0.28	0.16	0.23	-0.26	-0.09	0.00	0.12	-0.12	0.38	1.00	0.61	0.58	-0.25	-0.23
Areal Sediment Loading	0.25	0.12	0.19	0.51	0.32	0.21	-0.52	0.31	-0.23	-0.57	0.33	-0.39	0.17	0.49	0.04	0.40	-0.33	0.61	1.00	1.00	0.22	0.35
Areal P Loading	0.30	0.16	0.09	0.41	0.23	0.25	-0.21	0.31	-0.22	-0.59	0.22	-0.28	0.22	0.46	0.09	0.31	-0.40	0.58	1.00	1.00	0.27	0.43
Silt Cover	0.62	-0.44	-0.12	-0.33	0.13	0.90	0.87	-0.47	0.58	-0.75	-0.05	0.33	-0.23	-0.25	0.47	0.09	-0.31	-0.25	0.22	0.27	1.00	0.63
Embeddedness	0.64	-0.38	-0.38	-0.16	-0.17	0.41	0.90	0.29	0.53	-0.46	-0.52	0.07	0.60	0.38	0.65	-0.07	-0.45	-0.23	0.35	0.43	0.63	1.00

Note: Correlation coefficients greater than or equal to 0.81 are statistically significant (P<0.05) and are shaded.







APPENDICES

INSTITUTIONAL RESOURCES ASSESSMENT

APPENDIX A INSTITUTIONAL RESOURCES ASSESSMENT

Watersheds mean different things to different interest groups. If you asked most people in the area of a watershed what it is "good for," you would probably get as many different answers as there are people. For a farmer a stream means drainage, or flooding, depending on the location and circumstances. For children, a stream is a neat place to play and explore. A birdwatcher could tell you about the eagles, geese and other waterfowl that inhabit the watershed. For local governments, a stream carries treated wastewater away from the community. Some citizens might be surprised to find that ultimately, some of their drinking water comes from streams in the watershed. Thus, a watershed is many things to many people. Unfortunately, not all uses of the creek and the watershed are compatible. Watershed stakeholders are a varied group, however, the uses all have something in common—water quality, the subject of Harza's diagnostic study (Adapted from Rick Obenshain, "Pigeon Creek—More than a Drainage Ditch." April 2000).

This appendix discusses potential institutional initiatives to maintain and improve the health of the Mississinewa watershed. Watersheds demand attention from a wide variety of stakeholders each with differing interests in the area. As a primary institution in the watershed, the SWCD is well placed to further involve these stakeholders. How can this and other institutions best accommodate the various interests of a watersheds' stakeholders?

Efforts to improve the Mississinewa watersheds' water quality would benefit from a Watershed Action Plan to catalyze best management practices. This conscious planning process involves visioning, team building activities, discussing for results goal setting, and evaluation. The planning team is comprised of a broad mix of stakeholders, working with local and state agencies to review existing data including this diagnostic study, develop a plan of work, target areas that need attention heighten public awareness, find funding sources, implement change plans and monitor and evaluate. Commencing implementation activities with issues of interest to a majority of stakeholders, such as: illegal dumping; filter strips (soil conservation); septic tanks; floatable bottles, will increase stakeholders' commitment to the process. Many resources can assist in this planning process including the "Watershed Action Guide for Indiana". A watershed action plan can also facilitate volunteer monitoring of streams and lakes. Volunteer monitoring programs expand information available and stretch funding.

The process of watershed planning can be facilitated various ways. If stakeholders decide to use steering committees, they should consider various management styles—e.g. consensus versus majority, and the USDA's Coordinated Resources Management. Regardless, the experience of other watershed groups indicates that the process of group-building should not be rushed by forcing rules and mission statements and agendas.

As part of, or separate from, this plan, institutional initiatives should begin with involving people. There are leaders in every community, individuals with a bevy of knowledge and interest that can create excitement. Identifying and including them will help to make positive change, inspire the planning process and gain respect from the community.

One of the major items to be addressed in improving watershed quality is behavioral change. What sort of incentives and disincentives further involve people in improving the watershed's environmental health? A well-represented watershed planning group can with creative incentives, and match them with the existing programs defined in the various watershed resources. The group can learn from the process of other successful historical change initiatives for ways to create momentum for success.

Education is the key to maintaining and improving the health of the watershed. Education can be a vehicle for behavioral change. We recommend that the watershed action plan group, or the SWCD, establish an education committee or liaison. The committee would raise awareness among landowners about soil and water resource problems and their control, and to build local support for an active watershed education program. The committee will identify education priorities, identify target audience(s), characterize each audience, establish measurable objectives, design effective education activities, determine constraints to success, implement the education plan and evaluate progress (Watershed Action Guide for Indiana, p. 6). Further, it would be important that natural resource conservation information, including soil conservation, be incorporated into elementary and secondary school curricula.

There are several existing tools available for educating the public in methods to reduce nonpoint source pollutants at their source. Two of these programs are Home-A-Syst and Farm-A-Syst. The public should be encouraged to participate in these programs as the reduction of contaminants before they can enter the surface water flow creates less stress on the entire watershed.

The IDNR has ten regional soil conservation education specialists to work with the SWCD's in identifying, developing and carrying out needed educational activities, directed primarily toward the land user. Further, the SWCDs, IDNR, and USDA all have extraordinary education resources, as do extension services at Purdue University. The Water Resources Action Guide for Indiana includes a set of materials for watershed steering committees. Indiana has empowered watershed stakeholder groups even more by offering them an existing network of watershed partnership coordinators, developed in 1997 and sponsored by the Indiana Association of Soil & Water Conservation Districts. Education tools exist and can and should be distributed widely.

Smaller watersheds generally will be simpler to implement and document change. For large watersheds, several pilot projects are recommended. Small watersheds give a sense of ownership to stakeholders, allowing them to champion issues of greatest concern to them.

The following is a list of recommended institutional initiatives. Some of these are already underway in Mississinewa. Others could be implemented by the IDNR and/or SWCD, in cooperation with other stakeholders.

- Enroll fields in the farming for maximum efficiency program.
- Develop a Best Management Practice display to feature at farm shows, workshops and field days throughout the watershed.
- Continue to inform farmers about BMPs: conservation buffers; conservation tillage; and nutrient management planning, to reduce the amount of chemicals and soil leaving fields.
- Encourage participation in existing education programs on nonpoint source pollution such as Home-A-Syst and Farm-A-Syst.
- Use LARE and Section 319 grants to install best management practices in collaboration with landowners.
- Hold tours highlighting agricultural BMPs.
- Hold a "Pesticide Recycle Day" for the County Solid Waste District
- Facilitate Nutrient Management Planning such as regular soil laboratory testing of fields for fertilizer requirements.
- Explore the possibility of becoming a priority area for the Environmental Quality Incentive Program.
- Seek more monies to cost-share installation of Best Management Practices.

- Define current watershed activities as pro-farmer.
- Disseminate educational programs to schools, community groups and the general public.
- Consider passage of a County-wide erosion control ordinance.
- Through local schools, hold a poster contest for Soil and Water Stewardship Week, and display the winners at local libraries.
- Sponsor workshops and conferences that adults learn about soil and water conservation issues.
- Promote the IDNR's annual tree sale.
- Promote and celebrate Arbor Day.
- IDNR Division of Forestry offers a "Virtual Forest Workshop" for secondary science teachers.

The upper Mississinewa Watershed is in an excellent place to share its successful efforts to maintain and improve the health of its watershed. With the implementation of some of the institutional initiatives discussed above, it will be able to continually scale-out this success, sharing its experience in watershed best management planning with other watersheds.

REFERENCES

Indiana Department of Environmental Management Office of Water Management. "Section 319 Nonpoint Source Program Grants." Sep. 1997.

Indiana Department of Natural Resources. "Hoosier Riverwatch"

LABORATORY RESULTS



The Nation's Drinking Water Laboratory

110 S. Hill Street South Bend, IN 40017 219,233,4777 800,332,4345 Fax: 219,233,8207 www.mastechnology.com

LABORATORY REPORT

Client: Harza Environmental Services. Inc.

Attn: Ed Belmonte

233 South Wacker Drive

Chicago, IL 60606

Report#: 494130-59

Priority: Standard Written

Status: Final

Project/Site: Mississinowa Watershed / 16749G

Samples Submitted: Thirty surface water samples

Copies to: None

Collected: 05/15/00

By: Client

Received: 05/16/00

REPORT SUMMARY

Eschericia Coli: Eschericia coli were detected in the samples submitted for analysis at the concentrations indicated..

Note: The sample submitted for eschericia coli analysis was received beyond the 30 hour holding time. The client was notified of the situation, and analysis was authorized by Ed Belmonte of Harza Environmental Services. Inc.

Kjeldahl Nitrogen: Kjeldahl nitrogen was detected in the samples submitted for analysis at the concentrations indicated.

Note: Kjeldahl nitrogen analysis was performed by Sherry Laboratories of Ft. Wayne, IN.

Nitrogen, Nitrate-Nitrite: Nitrogen, nitrate-nitrite was detected in the samples submitted for analysis at the concentrations indicated.

Total Phosphorus: Total phosphorus was detected in eleven of twelve samples submitted for analysis at the concentrations indicated.

Conductivity: The conductivity of the samples submitted for analysis is indicated on the following pages.

pH: The pH of the samples submitted for analysis is indicated on the following pages.

Turbidity: Turbidity was detected in the samples submitted for analysis at the levels indicated.

Continued on the following page

Report#: 494130-59

REPORT SUMMARY - Continued

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (219) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories (div. of MAS Technology Corporation).

REVIEWED BY:

DATE: 🌽

FINALIZED BY:

DATE: 6-19-6

Report#: 494130-59

CONDUCTIVITY —Surface Water

Lab#	Site Description	MRL	Resu	lts
494134	UM 1 Mud Creek	0.1	710	umho/cm
494139	UM 2 Clear Creek	0.1	710	umho/cm
494144	UM 3 Miller Creek	0.1	730	umho/cm
494149	UM 4 Hasshman Creek	0.1	680	umho/cm
494154	UM 5 Jordon Creek	0.1	670	umho/cm
494159	UM 6 Goshen Creek	0.1	710	umho/cm

Analyzed: 05/17/00

Analyst: SK

Method #: 2510 B

E. COLI-Surface Water

Lab#	Sampling Point		Results
494130	UM 1 Mud Creek	70	cfu/100mL
494135	UM 2 Clear Creek	20	cfu/100mL
494140	UM 3 Miller Creek	10	cfu/100mL
494145	UM 4 Hasshman Creek	50	cfu/100mL
494150	UM 5 Jordon Creek	10	cfu/100mL
494155	UM 6 Goshen Creek	30	cfu/100mL

Analyzed: 05/16/00/ 16:10-16:37

Analyst: JT

Method#: SM 9213 D

KJELDAHL NITROGEN -Surface Water

Lab#	Site Description	MRL	Result	s
494131	UM 1 Mud Creek	1.0	2.1	mg/L
494136	UM 2 Clear Creek	1.0	2.3	mg/L
49414 1	UM 3 Miller Creek	1.0	2.2	mg/L
494146	UM 4 Hasshman Creek	1.0	1.9	mg/L
494151	UM 5 Jordon Creek	1.0	4.5	mg/L
494156	UM 6 Goshen Creek	1.0	1.7	mg/L

Analyzed: 06/05/00

Analyst: Sherry Labs

Method #: EPA 351.4

Client: Harza Environmental Services, Inc. Report#: 494130-59

NITROGEN, NITRATE-NITRITE—Surface Water

Lab#	Site Description	MCL	MRL	Results	5
494132	UM 1 Mud Creek	10	0.5	9.4	mg/L
494137	UM 2 Clear Creek	10	0.5	7.8	mg/L
494142	UM 3 Miller Creek	10	0.5	5.9	mg/L
494147	UM 4 Hashman Creek	10	0.5	3.6	mg/L
494152	UM 5 Jordon Creek	10	0.5	16	mg/L
494157	UM 6 Goshen Creek	10	0.5	9.9	mg/L

Analyzed: 05/17/00 Analyst: SK Method #: 353.2

pH—Surface Water

Lab#	Site Description	Results
494134	UM 1 Mud Čreek	8.3 pH units
494139	UM 2 Clear Creek	8.3 pH units
494144	UM 3 Miller Creek	8.5 pH units
494149	UM 4 Hasshman Creek	8.2 pH units
494154	UM 5 Jordon Creek	9.0 pH units
494159	UM 6 Goshen Creek	8.2 pH units

Analyzed: 05/16/00 Analyst: SK Method #: 150.1

Report#: 494130-59

TOTAL PHOSPHORUS—Surface Water

Lab #	Site Description	MRL	Results	3
494132	UM 1 Mud Creek	0.05	0.09	mg P/L
494137	UM 2 Clear Creek	0.05	0.08	mg P/L
494142	UM 3 Miller Creek	0.05	0.15	mg P/L
494147	UM 4 Hasshman Creek	0.05	0.06	mg P/L
494152	UM 5 Jordon Creek	0.05	0.07	mg P/L
494157	UM 6 Goshen Creek	0.05	0.10	mg P/L

Analyzed: 05/17/00 Analyst: EE Method #: 4500-P E

DISSOLVED PHOSPHORUS—Surface Water

Lab #	Site Description	MRL		Result	s
494133	UM 1 Mud Creek	0.05		0.05	mg P/L
494138	UM 2 Clear Creek	0.05	<	0.05	mg P/L
494143	UM 3 Miller Creek	0.05		0.13	mg P/L
494148	UM 4 Hasshman Creek	0.05	<	0.05	mg P/L
494153	UM 5 Jordon Creek	0.05		0.05	mg P/L
494158	UM 6 Goshen Creek	0.05		0.09	mg P/L

Analyzed: 05/18/00 Analyst: EE Method #: 4500-P E

TURBIDITY—Surface Water

Lab#	Site Description	MRL	Result	ts
494134	UM 1 Mud Creek	0.10	1.9	NTU
494139	UM 2 Clear Creek	0.10	1.5	NTU
494144	UM 3 Miller Creek	0.10	1.2	NTU
494149	UM 4 Hasshman Creek	0.10	1.9	NTU
494154	UM 5 Jordon Creek	0.10	3.1	NTU
494159	UM 6 Goshen Creek	0.10	4.3	NTU

Analyzed: 05/16/00 Analyst: EE Method #: 180.1

Client: Harza Environmental Services, Inc. Report#: 494130-59

REFERENCES AND DEFINITIONS OF TERMS.

Disinfectants/Disinfection By-Products (D/DBP) Analyses in Water

References:

1. EPÁ-600/4-79-020

Methods for Chemical Analysis of Water and Wastes, 1983

2. Standard Methods For the Examination of Water and Wastewater 3. Methods for the Determination of Organic Compounds in Drinking

Water: EPA /600/4/4-88/039

MCL = (Maximum Contaminant Levels) are the maximum allowable concentrations of regulated parameters in public drinking water supplies. Monitoring requirements for public supplies are not currently applicable to private (residential) water systems.

MRL = EHL's Minimum Reporting Limit

< = "less than." This number is the lowest reportable value by the procedure used for analysis.

 $\sqrt{}$ = If dilutions were required for quantitation of specific parameters, they are indicated by a $(\sqrt{})$ preceding the result.

1 mg/L = 1 milligram per liter = 1 part per million (ppm)

NTU = Nessler Turbidity Units

E. coli

Analytical technique:

Membrane Filtration

Reference:

Standard Methods For Examination of Water and Wastewater

Vol. 17, 1989

1 cfu = 1 Colony Forming Unit = a bacteria colony presumed to have originated from a single bacterium present in the sample.



SHERRY LABORATORIES --SHERRY LABS-- TEST REPORT Work Order # 00-06-905

ived: 06/30	/00		07/07/0	/oo	10:39:20			
PORT HARZA	ENGINEERING CO.		PREPARED) <u>s</u>	Sherry Laboratorie	es	7	
TO 233 SC	UTH WACKER		BY	7 <u>2</u>	2203 S. Madison			
CHICAG	O IL 60606			P	P.O. Box 2847		plant Bon	_
				M	Muncie, Indiana 47	7307-0847	CERTIFIED BY	
FTEN ED BEL	MONTE		ATTEN	1 <u>E</u>	Environmental Labo	ratory	_	
			PHONE	<u>(</u>	(765) 747-9000		CONTACT LISA N	
IENT <u>HARZA</u>	ENG SAMPL	ES <u>6</u>						
PANY <u>HARZA</u>	ENGINEERING CO.				Stanley D. W	lest		
LITY				_	Director for Envi	ronmental Se	rvices	
			Certifie	ed	by A2LA# 0174-03	IN# C-18-0	2 OK#8933 IN#M-18-5	
			The	ıe.	results relate or	ly to the sai	mples tested	
K ID WINCHE	STER STREAM WATER							
AKEN 6-30-0	0							
RANS HAND D	ELIVERED							
TYPE WATER								
o. #								
DICE under	separate cover							
AMPLE IDENT	TETCATION				TEST CODES and NA	on been STM	this workorder	
ITE #1 MID		MERC	E COLI		THE COURS AND IN	and aped on	mis workdidel	
ITE #2 CLEA		PIP BC	- COLL			-		
ITE #3 MILI								
ITE #4 HARS								

ITE #5 VORDON ITE #6 GOSHEN

TOTAL PAGES OF THIS REPORT:
THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL,
WITHOUT THE WRITTEN APPROVAL OF SHERRY LABORATORIES

Lisa Nation 765-213-5153 Stan West Page 🔏 LAB I.D. 0006905-01A

DATE REPORTED: 07/07/00

KE 06/30/00 17:00 07/05/00

SHERRY LABORATORIES

COLISURE 7400/100ML E.COLI/+ NO GROWTH ND

SAMPLE DESCRIPTION SITE #1 NID CREEK

DATE COLLECTED: 06/30/00 09:22 TEMPERATURE REC'D/PLATED:

E. COLI

Analyst Date Date Reference Detection Buffer Positive Negative Envair Analyte Initials Method Limit Lot# Lot# Control Control Count

1/100ML

SM063000

SM9213D

SHERRY LABORATORIES

SM063000 COLISURE 810/100ML E.COLI/+ NO GROWTH ED

DATE COLLECTED: 06/30/00 09:17

SAMPLE DESCRIPTION SITE #2 CLEAR CREEK

TEMPERATURE REC D/PLATED:

E. COLI

							w- ** -	Result	Positive	Negative	
Analyte	Analyst Initials	Date Received	Date Completed	Reference Method	Detection Limit	Buffer Lot#	Media Lot#	Kesuit	Control	_	Count

KE 06/30/00 17:00 07/05/00 SM9213D 1/100ML

ge 4 LAB I.D. 0006905-03A DATE REFORTED: 07/07/00

KE 06/30/00 17:00 07/05/00

E TO IN

SHERRY LABORATORIES

840/100ML E.COLI/+ NO GROWTH ND

SAMPLE DESCRIPTION SITE \$3 MILLER CREEK

DATE COLLECTED: 06/30/00 09:09

TEMPERATURE REC'D/PLATED: ______

E. COLI

Buffer Positive Regative Envalr Analyst Date Date Reference Detection Initials Received Method Limit Lot# Lot# Control Control Count Analyte

SM9213D

1/100ML

SM063000

COLISURE

DAD I.D. DOUGSUS-VER DATE RECORDED: 91/01/00

KE 06/30/00 17:00 07/05/00 SM9213D

SAMPLE DESCRIPTION SITE #4 HARSHMAN
DATE COLLECTED: 06/30/00 08:59

TEMPERATURE REC'D/PLATED:

E. COLI

SHERRY LABORATORIES

	Analyst	Date	Date	Reference	Detection	Buffer	Media	Result	Positive	Negative Enva
Analyte	Initials	Received	Completed	Method	Limit	Lot#	Lot#		Control	Control Coun

Laboratory Representative

1/100ML SM063000 COLISURE 720/100ML E.COLI/+ NO GROWTH ND

Page	1.	LAB I.D.	0006905-05A	DATE REPORTED:	07/07/00
rage	62	LMB I.D.	0000303-03K	DAID KEFORIED.	01/01/00

SHERRY LABORATORIES

SAMPLE DESCRIPTION SITE #5 VORDON DATE COLLECTED: 06/30/00 08:50 TEMPERATURE REC'D/PLATED: _____

Analyst Date Date Reference Detection Buffer Media Result Positive Negative EnvAir Control Count Initials Limit Lot# Lot Control Analyte Received Completed 1/100ML COLISURE 1320/100ML E.COLI/+ NO GROWTH ND E. COLI KE 06/30/00 17:00 07/05/00 SM9213D SM063000

> in alega t. Laboratory Representative

LAB I.D. <u>0096905-06A</u> DATE REPORTED: <u>07/07/00</u>

KE 06/30/00 17:00 07/05/00

Page

E. COLT

DATE COLLECTED: 06/30/00 09:28

TEMPERATURE REC'D/PLATED: _____

(00 Street)

SM063000

SHERRY LABORATORIES

COLISURE 340/100ML B.COLI/+ NO GROWTH ND

Analyst Date Date Reference Detection Buffer Media Result Positive Negative EnvAir Analyte Initials Received Completed Method Limit Lot# Lot# Control Control Count

1/100ML

SM9213D

Tu dya



Testing Today - Protecting Tomorrow w

1	SE	ERRY LABS	TEST REPORT	Work Order # 00-10-194
ved:	10/06/00	11/07/	00 08:08:57	
ORT	HARZA ENGINEERING CO.	PREPARED	Sherry Laboratories	
TO	233 SOUTH WACKER	ВУ	2203 S. Madison	— 1/1/h
	CHICAGO IL 60606		P.O. Box 2847	
			Muncie, Indiana 47307-084	_ ~
TEN	ED BELMONTE		Environmental Laboratory	
			(765) 747-9000	CONTACT LISA N
	HARZA ENG SAMPLES			
	HARZA ENGINEERING CO.			
ITY				C-18-02 OK#8933 IN#M-18-5
		Th	e results relate only to t	he samples tested
TD	Winchester Stream Water			
	10/6		ly Reported on 10/10/00.	
	Hand delivered			
	water	- Correc	ted report 11/7/00	wc
			,	
	20100207	_		
MPLE	IDENTIFICATION		TEST CODES and NAMES use	d on this workorder
Sit	e#1 Mud Creek M	FEC E COLI		
Sit	e#2 Clear Creek			
Sit	e#3 Miller Creek			
Sit	e#4 Harshman Creek			
Sit	e#5 Jordan Creek			
Sit	e#6 Goshen Creek			

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SAMPLE DESCRIPTION UN Site#1 Mud Creek TEMPERATURE REC'D/PLATED:

DATE COLLECTED: 10/06/00 10:22

SHERRYLaboratories

Testing Today - Protecting Tomorrow w

Analyte	Analyst Initials	Date Received	Date Completed	Reference Method	Detection <u>Limit</u>	Buffer Lot#	Media Lot#	Result	Positive Control	•	EnvAi:
E. COLI	LN	10/06/00 14:20	10/09/00	SM9213D	1/100ML	SM090200	100600mT	54000/100	E.COLI/+	NO GROWTH	ж

E. COLI

LAB I.D.

0010194-02A

DATE REPORTED: 11/07/00

10/06/00 14:20 10/09/00

SAMPLE DESCRIPTION UM Site#2 Clear Creek

LN

DATE COLLECTED: 10/06/00 10:13 TEMPERATURE REC'D/PLATED: **SHERRY**Laboratories Testing Today - Protecting Tomorrow

Analyst Date Date Reference Detection Buffer Media Result Positive Negative EnvAir Analyte Initials Received Completed Method Limit Lot# Lot# Control Control Count

1/100ML

SM090200

100600mT 74000/100 E.COLI/+ NO GROWTH ND

SM9213D

PALE REPORTED: 41/01/08

SAMPLE DESCRIPTION DM Site#3 Miller Creek

SHERRYLaboratories

DATE COLLECTED: 10/06/80 10:03 TEMPERATURE REC'D/PLATED:

Testing Today - Protecting Tomorrow w

Analyte	Analyst <u>Initials</u>	Date Received	Date <u>Completed</u>	Reference Method	Detection Limit	Buffer Lot#	Media Lots	Result.	Positive Control		EnvAir Count
E. COLI	LN	10/06/00 14:20	10/09/00	SM9213D	1/100ML	SM090200	100600mT	10200/100	E.COLI/+	NO GROWTH	ND.

Laboratory Representative

100600mT 10200/100 E.COLI/+ NO GROWTH ND

LAB I.D.

0010194-04A

DATE REPORTED: 11/07/00

SHERRYLaboratories

SAMPLE DESCRIPTION UM Site#4 Harshman Creek DATE COLLECTED: 10/06/00 09:53

TEMPERATURE REC'D/PLATED:

Testing Today -- Protecting Tomorrow »

Analyte	Analyst <u>Initials</u>	Date <u>Received</u>	Date Completed	Reference <u>Mathod</u>	Detection Limit	Buffer Lot#	Media Lots	Result	Positive Control	Regative Control	Envaix Count
E. COLI	LN	10/06/90 14:20	10/09/00	SM9213D	1/100ML	SM090200	100600mT	3300/100	R.COLI/+	NO GROWTH	ND

10/06/00 14:20 10/09/00

SAMPLE DESCRIPTION UN Site\$5 Jordan Creek
DATE COLLECTED: 10/06/00 09:43

TEMPERATURE REC'D/PLATED:

E. COLI

SHERRY

SHERRY Laboratories
Testing Today - Protecting Tomorrow.

Analyte	Analyst Initials	Date Received	Date Completed	Reference Method	Detection Limit	Buffer Lot#	Media Lot#	Result	Positive Control	Regative EnvAir

1/100ML

SM090200

SM9213D

Mi Alex Laboratory Representative

100600mT 14000/100 E.COLI/+ NO GROWTH

LAB I.D. 0010194-06A

DATE REPORTED: 11/07/00

SHERRYLaboratories

DATE COLLECTED: 10/06/00 10:31 TEMPERATURE REC'D/PLATED:

SAMPLE DESCRIPTION UM Site#6 Coshen Creek

Testing Today - Protecting Tomorrows

Analyst Date Date Reference Detection Buffer ¥edia Result Positive Negative Envaix Analyte Initials Received Completed Method Limit Lot# Lot# Control Control Count E. COLI LN 10/06/00 14:20 10/09/00 SM9213D 1/100ML SM090200 100600mT 1080/100 E.COLI/+ NO GROWTH



Environmental Health Laboratories

The Nation's Drinking Water Laboratory

110 S. Hill Street
South Bend, IN 46617
219.233.4777
800.332.4345
Fax: 219.233.8207

LABORATORY REPORT

Client: Harza Environmental Services, Inc.

Attn: Ed Belmonte

233 South Wacker Drive

Chicago, IL 60606

Report#: 539405-28a2

Priority: Standard Written

Status: Amended

Project/Site: Multiple

Samples Submitted: Twenty-four drinking water samples

Copies to: None

Collected: 10/06/00

By: Client

Received: 10/07/00

REPORT RESULTS

Twenty-four drinking water samples were submitted for multiple parameter analyses.

Note: The original result for total phosphorus in the sample UM Site #6 Goshen Creek was 0.43 mg/L as P. This result was calculated with the incorrect calibration curve, due to laboratory error. When the result was calculated with the correct calibration the QC fell outside of acceptance limits. The new result is reported in the result section of the report and was re-analyzed outside of holding time.

Note: This report was amended on 11/08/00 to correct the problem described in the above note. This report was further amended to report all dissolved phosphorus as total phosphorus.

Detailed quantitative results are presented on the following pages.

We appreciate the opportunity to provide you with this analysis. If you have any questions concerning this report, please do not hesitate to call us at (219) 233-4777.

Note: This report may not be reproduced, except in full, without written approval from Environmental Health Laboratories (div. of MAS Technology Corporation).

REVIEWED BY:

amput.

FINALIZED BY:

DATE: 3-2-01

DATE: 3/2/2001

Page 1 of 5

Report#: 539405-28a

GENERAL CHEMISTRY—Drinking Water

Site Description: UM Site #1 Mud Creek Lab#: 539405-08

Parameter Conductivity Nitrogen (Kjeldahl) pH Phosphorus, Total Phosphorus, Total Turbidity	Method 2510 B 351.4 EPA-150.1 SM 4500-PE SM 4500-PE EPA-180 1	SMCL NA NA 6.5-8.5 NA NA	MRL 0.1 1.0 NA 0.05 0.05	V	Results 430 umhos/cm# 10.5 mg/L 7.6 pH units 0.69 mg/L as P 0.50 mg/L as P
Turbidity	EPA-180.1	1	0.1	\checkmark	74 NTU

If dilutions were required for quantitation of specific parameters, they are indicated by a $(\sqrt{})$ preceding the result.

= Adjusted to 25 degrees C

NA = Not Applicable

Note: Nitrogen (Kjeldahl) analysis performed by Sherry Laboratories, Columbus, IN.

Analyzed: 10/07 to 10/17/00 Analyst: EE / SK / KL / BR / JNW(Sherry)

Site Description: UM Site #2 Clear Creek Lab#: 539409-12

Parameter Conductivity Nitrogen (Kjeldahl) pH Phosphorus, Total Phosphorus, Total Turbidity	Method 2510 B 351.4 EPA-150.1 SM 4500-PE SM 4500-PE	SMCL NA NA 6.5-8.5 NA NA	MRL 0.1 1.0 NA 0.05 0.05	77,	7.7 0.48 0.36	umhos/cm# mg/L pH units mg/L as P mg/L as P
rarbidity	EPA-180.1	1	0.1	√	100	NTU

If dilutions were required for quantitation of specific parameters, they are indicated by a $(\sqrt{})$ preceding the result.

= Adjusted to 25 degrees C

NA = Not Applicable

Note: Nitrogen (Kjeldahl) analysis performed by Sherry Laboratories, Columbus, IN.

Analyzed: 10/07 to 10/17/00 Analyst: EE / SK / KL / BR / JNW(Sherry)

Continued on the following page

Report#: 539405-28a

GENERAL CHEMISTRY—Drinking Water

Site Description: UM Site #3 Miller Creek Lab#: 539413-16

Parameter Conductivity Nitrogen (Kjeldahl) pH Phosphorus, Total Phosphorus, Total Turbidity	Method 2510 B 351.4 EPA-150.1 SM 4500-PE SM 4500-PE EPA-180.1	SMCL NA NA 6.5-8.5 NA NA	MRL 0.1 1.0 NA 0.05 0.05 0.1	7 7 7	7.7 0.42	Its umhos/cm# mg/L pH units mg/L as P mg/L as P NTU
---	---	---	--	-------	-------------	---

If dilutions were required for quantitation of specific parameters, they are indicated by a $(\sqrt{})$ preceding the result.

= Adjusted to 25 degrees C

NA = Not Applicable

Note: Nitrogen (Kjeldahl) analysis performed by Sherry Laboratories, Columbus, IN.

Analyzed: 10/07 to 10/17/00 Analyst: EE / SK / KL / BR / JNW(Sherry)

Site Description: UM Site #4 Harshman Creek Lab#: 539417-20

Parameter Conductivity Nitrogen (Kjeldahl) pH Phosphorus, Total Phosphorus, Total Turbidity	Method 2510 B 351.4 EPA-150.1 SM 4500-PE SM 4500-PE	SMCL NA NA 6.5-8.5 NA NA	MRL 0.1 1.0 NA 0.05 0.05	77	7.8	its umhos/cm# mg/L pH units mg/L as P mg/L as P
lurbidity	EPA-180.1	1	0.1	V	92	NTIL

If dilutions were required for quantitation of specific parameters, they are indicated by a $(\sqrt{})$ preceding the result.

= Adjusted to 25 degrees C

NA = Not Applicable

Note: Nitrogen (Kjeldahl) analysis performed by Sherry Laboratories, Columbus, IN.

Analyzed: 10/07 to 10/17/00 Analyst: EE / SK / KL / BR / JNW(Sherry)

Continued on the following page

Report#: 539405-28a

Lab#: 539421-24

GENERAL CHEMISTRY—Drinking Water (Continued)

Site Description: UM Site #5 Jordan Creek

Parameter Method SMCL MRL Results Conductivity 2510 B NA 0.1 590 umhos/cm# Nitrogen (Kjeldahl) 351.4 NA 1.0 3.04 mg/L EPA-150.1 SM 4500-PE Hq 6.5-8.5 NA 7.8 pH units Phosphorus, Total Phosphorus, Total NA 0.05 0.73 mg/L as P SM 4500-PE NA 0.05 0.66 mg/L as P Turbidity EPA-180.1 0.1 NTU

If dilutions were required for quantitation of specific parameters, they are indicated by a (\lor) preceding the result.

= Adjusted to 25 degrees C

NA = Not Applicable

Note: Nitrogen (Kjeldahl) analysis performed by Sherry Laboratories, Columbus, IN.

Analyzed: 10/07 to 10/17/00 Analyst: EE / SK / KL / BR / JNW(Sherry)

Site Description: UM Site #6 Goshen Creek Lab#: 539425-28

Parameter Conductivity Nitrogen (Kjeldahl) pH Phosphorus, Total Phosphorus, Total Turbidity	Method 2510 B 351.4 EPA-150.1 SM 4500-PE SM 4500-PE EPA-180.1	SMCL NA NA 6.5-8.5 NA NA	MRL 0.1 1.0 NA 0.05 0.05	√	7.5 0.48 0.55	umhos/cm# mg/L pH units mg/L as P mg/L as P
Toroidity	EFA-180.1	1	0.1	V	88	NTU

If dilutions were required for quantitation of specific parameters, they are indicated by a $(\sqrt{})$ preceding the result.

= Adjusted to 25 degrees C

NA = Not Applicable

Note: Nitrogen (Kjeldahl) analysis performed by Sherry Laboratories, Columbus, IN.

Analyzed: 10/07 to 11/07/00 Analyst: EE / SK / KL / BR / JNW(Sherry)

REFERENCES AND DEFINITIONS OF TERMS

General Chemistry

NO NE ENVE EDITOR TELE

References: 1. EPA-600/4-79-020

Client: Harza Environmental Services, Inc.

Methods for Chemical Analysis of Water and Wastes

2. Standard Methods For the Examination of Water and Wastewater

Report#: 539405-28a

Vol. 17, 1989

MRL = EHL's Minimum Reporting Limit

Results: Values presented in the result column represent the lowest reportable value for a parameter after correcting for all sample dilutions.

1 mg/L = 1 milligram per liter = 1 part per million (ppm).

<= "less than." This number is the lowest reportable value by the procedure used for analysis after factoring in all dilutions.</p>

1 umho/cm = 1 micromho per centimeter = unit of specific conductance

APPENDIX C FIELD DATA SHEETS

4M-1 5/15/00

OA Manual (6th Update) - Fish - September 30, 1989

Procedure No. Revision No.

WOPA-SWS-3

Date Issued Date Effective

9-30-89 9-30-89

Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Oualitative Habitat Evaluation Index (QHEI).

Onio EPA Silo Doc Stein Mud Cr	eriplion Shool - Fisi ee£	RMDate	QHEI SCORE: 66.5
		Crewc	ESB/CWR
TYPE POCL RIF CO-BLDER /SU-BS[10] CO-BCLDER [9] CO-COBBLE [8] CO-COBBLE [8] CO-MUCK [2]	10-GRAVEL [7] X X Sul QASANO [6] X O-LII QO-BEDROCKISI ATTI QO-DETRITUS[3] Q-SI QO-ARTIFIC.[0] Q-SI	SUBSTRATE QUALIT DESTRICT OF ISIN (Creek all) MESTONE (172)-RIP/RAP [0] LLS (1] OHARDPAN [0] ANOSTONE [0] HALE [-1]	Y SUBSTRATE SCORE: 4 SILGOYM (Shock One) SILGOYM (Shock One) SILTHEAYY (2)OSILT MODERATE (-1) SILTHORNAL (0) O SILTHEE (1) ELISM OF EMBORDERS (Check One) O EXTENSIVE (-2)O — MODERATE(-1)
TOTAL NUMBER OF SUBSTRATE	TYPES: 0 4 (2) 0 - <- 4 [0] 0-C	CAL FINES (-2)	
NOTE: (Ignore studge that originate COMMENTS	es from point-sources; score is based	ou ustrus srocustes)	M-rowiol D-NONEII
2] INSTREAM COVER TYPE (CO-UNDERCUT BANKS [1]	heck All That Apply)		COVER SCORE: 13 AMOUNTICHECK ONLY One of check 2 and AVERAGE
DEOVERHANGING VEGETATION	OEEP POOLS [2]	□ -0x3cws (1)	0 - EXTENSIVE > 75% [11]
		G-AGUATIC MACROPHYTES	(1) MODERATE 25-75 % [7]
SHALLOWS (IN SLOW WATER	(1) (1) G-800F0EB2	E-LOGS OR WOODY DEBRIS	S [1] O - SPARSE 5-25% [3]
COMMENTS:	. *		U - NEARLY ABSENT < 5%[1]
COMMENTS.			
SIMUCSITY DEVELOP	neck ONLY One PER Category OR I		CHANNEL: 3
D - HIGH [4] D - EXCEL	LENT [7] Q . NONE [6] Q .	HIGH [3] D - SNAGGI	
ACOERATE (3) DX: GOCO	[5] A RECOVERED (4)	MODERATE [2] CI RELOCA	
(1 - LOW (2)	RECOVERING [] Q.		REMOVAL D - LEVEED
O - NONE[1] O - POOR	II O - RECENT OR NO	Q - DREDGE	
	RECOVERY [1]		SIDE CHANNEL MODIFICATIONS
COMMENTS:		0.000	SIDE CLANATE WOOLLICKS
4] RIPARIAN ZONE AND BANK EI *River Right Looking Downstream*			ر د د د د د د د د د د د د د د د د د د د
River Right Looking Downstream RIPARIAN WIDTH	EBOSION/BUNGEE - ELOCO PLAIN	CUAL TY	BANK EPOSION
River Right Looking Downstream RIPARIAN WIDTH L. R. (Per Bank)	ERCSION/RUNGER - F. DOD PLAIN L. R. (Most Predominant Per Bank)	CUAL TY L. R. (Per Bank)	BANK EPOSION
River Right Looking Downstream <u>RIPA FLAN WIDTH</u> L R (Per Bank) D J*WIDES Som [4] D J*WIDES AT E 10-50 [3] AM*-NARROW S-10m [2]	EROSION/RUNOFF - F. DOD PLAIN L.R. (MOST Predominant Per Bank) DO-FOREST, SWAMP [D] MOSOPEN PASTURE/ ROWCROP(C DO-RESIO_PARK, NEW FIELD [1]	CUALITY L. R. (Per Bank) D. DURBAN OR INDUSTRU D. O. SHRUB OR OLD FIELD O. CONSERV. TILLAGE (1)	BANK ERCSION ALIOI MENONE OR LITTLE (3) (2) O OMCOGRATE (2) O OHEAVY OR SEVERE(1)
River Right Looking Downstream RIDARIAN WIGTH L. R. (Per Bank) D. T. WIDE- Som [4] D. T. MODERATE 10-50 [3]	EROSION/RUNOFF - F. DOD PLAIN L.R. (MOST Predominant Per Bank) DO-FOREST, SWAMP [D] MOSOPEN PASTURE/ ROWCROP(C DO-RESIO_PARK, NEW FIELD [1]	CUALTY L R (Per Bank) DOURBAN OR INDUSTRU L C D-SHRUB OR OLD RELD	BANK ERCSION ALIOI MENONE OR LITTLE (3) (2) O OMCOGRATE (2) O OHEAVY OR SEVERE(1)
"River Right Looking Downstream" RIPARIAN WICT' L R (Per Bank) CID "WIDES 50m [4] CID "MODERATE 10-53 [7] AM "NARROW 5-10m [2] CID "VERY NARROW 1-5m [1]	EROSION/RUNOFF - F. DOD PLAIN L.R. (MOST Predominant Per Bank) DO-FOREST, SWAMP [D] MOSOPEN PASTURE/ ROWCROP(C DO-RESIO_PARK, NEW FIELD [1]	CUALITY L. R. (Per Bank) D. DURBAN OR INDUSTRU D. O. SHRUB OR OLD FIELD O. CONSERV. TILLAGE (1)	BANK ERCSION ALIOI MENONE OR LITTLE (3) (2) O OMCOGRATE (2) O OHEAVY OR SEVERE(1)
** ** ** ** ** ** ** ** ** ** ** ** **	EECSION/RUNGEE - ET DOD PLAIN L. R. (Most Predominant Per Bank) 20-FOREST, SWAMP [3] 20-FOREST, SWAMP [3] 20-RESIO_PARK.NEW FIELD [1] 20-FENCED PASTURE [1]	CUALITY L. R. (Per Bank) D. DURBAN OR INDUSTRU D. O. SHRUB OR OLD FIELD O. CONSERV. TILLAGE (1)	BANK EROSION AL(a) A MONE OR LITTLE (3) (3) OMCJERATE(3) (4) OHEAVY OR SEVERE(1) IN (c)
"River Right Looking Downstream" RIPARIAN WICT' L R (Per Bank) CD"-WIDES SOM [4] CD"-WIDES SOM SIEPLE/RUN OL	EECSIONALINGEE - EL DOD PLAIN L R (Most Predominant Per Bank) DO-FOREST, SWAMP (I) DO-FOREST, SWAMP (II) DO-RESIOL-PARKNEW FIELD (II) DO-FENCED PASTURE (II) DO-FENCED PASTURE (II)	L R (Per Bank) DOURBAN OR INDUSTRIC COSTRUE OR CLO FIELD ODCONSERV, TILLAGE () ODMINING-CONSTRUCTIO	BANK EPOSION ALIQI A MONE OR LITTLE [3] [2] D OMEGGERATE,[2] [1] D OHEAVY OR SEVERE[1] ON [0] POOL: 6
"River Right Locking Downstraam" ELR (Per Bank) CD "WIDES 50m [4] CD "WIDES 50m [4] CD "WIDES 50m [4] CD "WIDES 50m [6] CD "WIDES 50m [6] CO "WIDES 50m [6] COMMENTS: DO "WIDES 50m [6] COMMENTS:	EECSION/RUNGEE - ELOCO 91 AIM I. R. (Most Predominant Per Bank) I. R. (Most Per Bank) I. R. (Most Per Bank) II. R. (Most Per Bank) III. R. (M	CUAL TO L R (Per Bank) COURSAN OR INDUSTRIC COURSAN OR INDUSTRIC COOCONSERV. TILLAGE (1) COOCONSERV. TILLAGE (1) COOMINING CONSTRUCTIO	BANK EBOSION ALICI A ENONE OR LITTLE [3] [2] O OMCOZRATE.[2] [3] O OHEAVY OR SEVERE[1] IN [0] POOL: 6
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"River Right Looking Downstraam" ELR (Per Bank) CD"-WIDE-Som [4] CD"-WIDE-Som [2] CD"-WIDE-Som [2] CD"-WIDE-Som [2] CD"-WIDE-Som [2] CD"-WIDE-SOM [3] CD"-WIDE-SOM [4] CD-SIM [6] CD"-PCC CD"-FIM [4] CD"-PCC	EECSION/RUNCEE - ELODO PI AIM LR (Most Predominant Per Bank) DO-FOREST, SWAMP [3] DO-FOREST, SWAMP [3] DO-FOREST, SWAMP [3] DO-FORESTO, PARK NEW FIELD [1] DO-FENCED PASTURE [1] IAUTY MICHEMOLOGY (Check 1) L WIDTH > RIFFLE WOTH [2]	CUALTY L R (Per Bank) DOURBAN OR INDUSTRIL COSARIUS OR CLO RELO COSCONSERV. TILLAGE (I) COSMINING-CONSTRUCTIC COSCONSERV. TILLAGE (I) COSCO	BANK ERCSION AL(I) A PNONE OR LITTLE [3] [2] O CHEAVY OR SEVERE[1] IN [0] POOL: 6 IRHENT VELOCITY DDIES[1]
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"River Right Looking Downstraam" RIPARIAN WITCTL LR (Per Bank) CD"-WIDES SOM [4] CD"-MODERATE 10-53 [3] AM-NARROW S-10m [2] CD"-NONE[0] COMMENTS: PRODUCIDE AND RIFFLERUN QL MAX OSETH [Check 1] D > Im [6] CQ-4-0.7m [2] D - c-4-0.7m [2] C-2-00 C-2-0.4m [1]	EECSION/RUNCEE - ELODO PI AIM LR (Most Predominant Per Bank) DO-FOREST, SWAMP [3] DO-FOREST, SWAMP [3] DO-FOREST, SWAMP [3] DO-FORESTO, PARK NEW FIELD [1] DO-FENCED PASTURE [1] IAUTY MICHEMOLOGY (Check 1) L WIDTH > RIFFLE WOTH [2]	CUALTY L R (Per Bank) DOURRAN OR INDUSTRIC DOSONSERV. TICLAGE; II DOMINING/CONSTRUCTIO POT RUN/GIETE C (Check All That Apply) O'TORRENTAL(-1) O'FAST[1] O'HOGERATE[1] O'HOGERATE[1] O'HOGERATE[1]	BANK ERCSION AL(I) A PNONE OR LITTLE [3] [2] O CHEAVY OR SEVERE[1] IN [0] POOL: 6 IRHENT VELOCITY DDIES[1]
"River Right Looking Downstraam"	EECSION/RUNCEE - EI COD 9: AIM L. R. (Most Predominant Per Bank) COPERST, SWAMP [3] COPERST, SWAMP [3] COPERSTOREST, SWAMP [3] COPERSTOREST AND ARTHUR [1] COPERSTOREST AND ARTHUR [1] COPERSTOREST AND ARTHUR [3] COPERSTOREST AND ARTHUR [3] COPERSTOREST AND ARTHUR [4] COPERSTOREST AND ARTHUR [4]	CUALTY L R (Per Bank) COURSAN OR INDUSTRU COURSAN OR INDUSTRU COURSERV. TILLAGE (1 COMMINING/CONSTRUCTION COMMINING/CONS	BANK EBOSION ALICI A PHONE OR LITTLE [3] [2] O OMCOGRAFIZ; [3] O OHEAVY OR SEVERE[1] IN [0] POOL: 6 INHENT VELOCITY DOIES[1] GERSTITUL[-1] [5 NO POOL[0]
"River Right Looking Downstraam" RIPARIAN WITCTL LR (Per Bank) CD"-WIDES SOM [4] CD"-MODERATE 10-53 [3] AM-NARROW S-10m [2] CD"-NONE[0] COMMENTS: PRODUCIDE AND RIFFLERUN QL MAX OSETH [Check 1] D > Im [6] CQ-4-0.7m [2] D - c-4-0.7m [2] C-2-00 C-2-0.4m [1]	EECSION/RUNCEE - EI COD 9: AIM L. R. (Most Predominant Per Bank) COPERST, SWAMP [3] COPERST, SWAMP [3] COPERSTOREST, SWAMP [3] COPERSTOREST AND ARTHUR [1] COPERSTOREST AND ARTHUR [1] COPERSTOREST AND ARTHUR [3] COPERSTOREST AND ARTHUR [3] COPERSTOREST AND ARTHUR [4] COPERSTOREST AND ARTHUR [4]	CUALTY L R (Per Bank) DOURRAN OR INDUSTRIC DOSONSERV. TICLAGE; II DOMINING/CONSTRUCTIO POT RUN/GIETE C (Check All That Apply) O'TORRENTAL(-1) O'FAST[1] O'HOGERATE[1] O'HOGERATE[1] O'HOGERATE[1]	BANK EBOSION ALICI A MONE OR LITTLE [3] [2] O OMCOGRATE [2] IN [0] POOL: 6 INHEMIT VELOCITY ODIEST 1] ITERMITTENT[-2]
"River Right Locking Downstraam" RISARIAM WIDT' LR (Per Bank) CD "WIDES 50m [4] CD "WIDES 50m [4] CD "WIDES 50m [4] CD "WIDES 50m [6] CO "WIDES 50m [6] CO "WIDES 50m [6] CO "WIDES 50m [6] DO "WIDES 50m [6] DO "WIDES 50m [6] CO "WIDES 50m [6] CO "WIDES 50m [6] CO 4-0.7m [2] CD <0.4m [1] CO COMMENTS:	EECSION/RUNGEE - ELOOD 9: AIM I. R. (Most Predominant Per Bank) I. R. (Most Pasture (1) I. R. (Most Pasture (1) I. R. (Most Pasture (1) I. WIDTH - RIFFLE WIDTH (1) I. WIDTH - RIFFLE W. [0] I. R. (MOST Pasture (1) RIFFLE W. (0) RIFFLE W. (0)	COALTY LR (Per Bank) COURSAN OR INDUSTRIE CO-CONSERV. TILLAGE [1 CO-MINING-CONSTRUCTION COMMINING-CONSTRUCTION COMMINING-CO	BANK EBCSION ALICI A PHONE OR LITTLE [3] [2] O OMCOZRATE[2] [0] O HEAVY OR SEVERE[1] IN [0] POOL: 6 IRHENT VELOCITY DDIES[1] ITERSTITUL[-1] TERMITTENT[-2] RIFFLE: 7
*** *** *** *** *** *** *** *** *** **	EECSION/RUNCEE - E-COD 9: AIM L R (Most Predominant Per Bank) DO-FOREST, SWAMP [0] WOODEN PASTURES (NOWCROPIC DO-RESIO, PARKINEW FIELD (1) DO-FENCED PASTURE (1) IAUTY (Check 1) L WIOTH - RIFFLE WIOTH [2] L WIOTH - RIFFLE WIOTH [1] L WIOTH < RIFFLE W. [0] PIEFLE FRUN SUBST DISTABLE (a.g. Cod	CALITY L R (Per Bank) DOURRAM OR INDUSTRIC DOCONSERV. TILLAGE; II DOMINING/CONSTRUCTIO CONCRETING/CONSTRUCTIO CONCRETING/CONSTRUCTION CONCRETING/CON	BANK EPOSION ALCI A MONE OR LITTLE [3] [2] O OMCJERATE [2] [] O OHEAVY OR SEVERE[1] IN [0] POOL: 6 DDIES [1] ITERMITTENT[-2] RIFFLE: 7 RIN SMESODEDNESS NSYE[-1] OMCJERATE[0]
"River Right Looking Downstraam" RIPARIAN WIDT'L R (Per Bank) CD "WIDES Som [4] CD "WIDES Som [4] CD "WIDES Som [6] CD "WOESTATE 10-50 [3] AND "NARROW 1-5m [8] CD "NONE[9] COMMENTS: DO "NONE[9] COMMENTS: COMMENTS: CO 4-0-7m [4] CO 4-0-7m [2] CO 4-0-7m [2] COMMENTS: CO COMMENTS: CO COMMENTS: CO C	EECSION/RUNCEE - ELODO PI AIM L R (Most Predominant Per Bank) DO-FOREST, SWAMP [0] DO-FOREST, SWAMP [0] DO-FOREST, SWAMP [0] DO-FOREST PARTURES (1] DO-FOREST PARTURES (1] IAUTY MORPHOLOGY (Check 1) L WIOTH - RIFFLE WIOTH [1] L WIOTH - RIFFLE WIOTH [1] L WIOTH < RIFFLE W. [0] PLEEL FRUN SUBST DISTABLE (19, 9, 000) DO-MOOL STABLE (19, 9, 000)	COALTY LR (Per Bank) COURSAN OR INDUSTRIA CONTRAIN OR INDUSTRIA CONSERV. TILLAGE (1) CONSERV. TILLAGE (1) CONSERV. AIT THAT APPHY) CONSERTIAL (-1) CONSERTIAL	BANK EBOSION ALIQI A MONE OR LITTLE [3] [2] O OMCOZRATE,[2] [] O OHEAVY OR SEVERE[1] NICO DOIEST 1 ITERSTITIAL(-1) DOIEST 1 ITERSTITIAL(-1) RIFFLE: ZIUN EMBEDOERNESS RISYE [-1] OMCOZRATE[3]
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"River Right Looking Downstraam" RIPARIAM WITCTL L R (Per Bank) C D "WIDS-Som [4] C D "WIDS-Som [4] C D "WIDS-Som [2] C Q 4-0, 11 C G A-0, 11 C G ENERALLY "S 10 cm, MAX SS [4] C GENERALLY S-10 cm, MAX SS [2] C GENERALLY S-10 cm [2]	EECSION/RUNCEE - ELODO PI AIM L R (Most Predominant Per Bank) DO-FOREST, SWAMP [0] DO-FOREST, SWAMP [0] DO-FOREST, SWAMP [0] DO-FOREST PARTURES (1] DO-FOREST PARTURES (1] IAUTY MORPHOLOGY (Check 1) L WIOTH - RIFFLE WIOTH [1] L WIOTH - RIFFLE WIOTH [1] L WIOTH < RIFFLE W. [0] PLEEL FRUN SUBST DISTABLE (19, 9, 000) DO-MOOL STABLE (19, 9, 000)	COALTY LR (Per Bank) COURSAN OR INDUSTRIA CONTRAIN OR INDUSTRIA CONSERV. TILLAGE (1) CONSERV. TILLAGE (1) CONSERV. AIT THAT APPHY) CONSERTIAL (-1) CONSERTIAL	BANK EPOSION ALIQI A MONE OR LITTLE [3] [2] O OMGJERATE.[2] [3] O OHEAVY OR SEVERE[1] IN [0] POOL: 6 IRHENT VELOCITY DODIEST 1 ITERSTITUL[-1] O NO POOL[0] ITERSTITUL[-1] O NO POOL[0] ITERSTITUL[-1] O NO POOL[0] ITERMITTENT[-2] RUN EMBEDDEDNESS INSINE [-1] O MODERATE[0] [1] ONO RIFFLE[0]
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UM-1 5/15/00

Rapid Bioassessment Protocol II

Biosurvey Field Data Sheet

Periphyton 0 Filamentous Algae 0 Macrophytes 0 0 = Absent/Not Observed	1 2 3 4 Sil 1 2 3 4 Ma 1 2 3 4 Fis 1 = Rare 2 = Common	0 1 ② 3 4
MACROBENTHOS QUALITATI	/E SAMPLE LIST	
Oligochaeta - (C)		List Families Present/Indicate Abundance
		Isogoda - MM HH WM MAH
	Anisoptera	THE THE THE THE MEN THE
Gastropoda		
Lymcaeidae - 1111 (4)		Coleopters
Shysthe -11 (2) Bivalvia	Zygoptera	Dryopidae - THE THE HHILL (23)
		Elmobe - 41(3)
	Piecopiera 114 114 114 114 114 114 114 114 114 11	
Ephemeroptera	14K 40	
Carino -1 (1)		Ceratorgania (p.) Gezzia 1 1
(1)	Trichoptera	Decapoda - I
Other	Helicopsyche - IIII	Vecasoda -
RIFFLE SAMPLE		
FUNCTIONAL FEEDING GROUPS	(Indicate No. of Individ	duals Representing Group)
Scrapers		
Shreddon	Filtering Collect EDING GROUPS (Indicate No. of Individual	to Describe
Observations 22	Total Org. in Sa	ample 53
ater temp = 17.7 °C Fond = 711 mm hos PH = 8.419 DO = 25.4 mg/L		

QA Manual (6th Update) - Fish - September 30, 1989 Procedure No.

WOPA-SWS-3 6

Revision No.

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Figure V-4-6. Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record additional information about the sampling site and adjacent area.

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	THIRD PAS	SS .	. 						RATING				
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	STREAM	WE see							HOIOS:	7-45/6		Car	
					GE WID	nt 12'	_AVERAGE	ретн:а	wx	€РТН <u>- 4</u> /			
	200'	15'	1.57	THS D			 			POOLGLD:RIF AI	JN .		
	100'	10'	6"	12"	3,5	+		+		P2007]		
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OA Manual (6th Update) - Fish - September 30, 1989

Procedure No. Revision No. WOPA-SWS-3

Date Issued Date Effective 9-30-89

Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Qualitative Habitat Evaluation Index (QHEI).

	Doscription S	12:7 - 100ni		Q:	HEI SCORE	: 74
Location UM - 2			<u> </u>	_crown_Est	3/aur -	
0.0-8LDER /SLA8S[10]	ONLYTHO SUBSTRATE TYP. XCL RIFFLE XO-GRAVEL [7] XX X Q Q-SAND [6] XX X Q Q-BEDROCK	POOL RIFFLE X X Sub X YOLIM	SUBSTRAT Check Citate (Check ESTONE (1) ESTONE	ck all) Si (RAP [0] C-SIL1	UBSTRATE	SCORE: 16 One! LT MODERATE [-1] O-SILT FREE [1]
COMMENTS	O O-OETRITUS O O-ARTIFIC.[0] STRATE TYPES: ① 4 [2]	[3]O-SA]O-SH Q <= 4 [0] O-CO	MUSTONE (0) MLE [-1] ML FINES [-2]	E 0-	TEMBINE (-2)	DEST (Check One) O-MODERATE(-1) O-MONE[1]
O-UNDERCUT BANKS [1]	TATION[1] SCROO	P POOLS [2] (D-OXSCWS [1] D-AQUATIC MACE B-LOGS OR WOOM	ROPHYTES [1]) DY DEBRIS [1]	COVER SI AMOUNTICHECK check 2 and AVE 0 - EXTENSIVE 2 MODERATE: 0 - SPARSE 5-25 0 - NEARLY ABS	ONLY One or FRAGE) - 75% [11] 25-75% [7] % [3]
COMMENTS:						
D - HIGH [4] D -	EXCELLENT [7] CHANN EXCELLENT [7] CHANN GOOD [5] FAIR [1] POOR [1] CHANN EXCELLENT [7]	ELIZATION STA	ABILITY MANUAL HIGH [D] DI	COIFICATIONS I - SNAGGING - RELOCATION - CANOPY REA - DREDGING	O-IMPO O-IMPO N O-ISLAN NOVAL O-LEVE	UND. IDS ED SHAPING
4] RIPARIAN ZONE AND B. *River Right Looking Downsti RIPARIAN WID TH	ream"			VERAGE per bi		RIAN: पि
		E - E 200 BI AIM			BANK ERCSIO	<u> </u>
L R (Per Bank)		minant Per Bank)				
0 3MIDE 20W [4]	PROFOREST, SW.		OCURSAN OR			
C D'AMODERATE 10-50 (RE/ ROWCROP(0)	CO-SHAUS OR C	DLO FIELD(2)	ASSCOM-O'TEK	TE(2)
QZ-NARROW S-10m [2]			DO-CONSERV. T		C CHEAVY O	R SEVERE(1)
□ □NONE[0]						
COMMENTS:						
POOUGLIDE AND RIFFLE/R	IUN QUALITY				Р	00L: 5
WAX DESTH (Check 1)	MOHOHO! OC	<u>×</u>	POY PRUM	GIEST & CURHE	AT VELOCITY	
D->1m(6)	(Check 1)		(Check All T	Tust Apply)		
C- 0.7-1m (4)	RIFFL > RIFFL	E MIDTH [2]	DTORRENTWU.	-1] Q'-EDDIS	S(1)	
25 50.4-0.7m [2] (0	D-POOL WIOTH - RIFFL	E WIDTH [1]	O'-FAST[1]	O'-INTER	ISTITIAL[-1]	C- NO POOL(0]
D- < 0.4m[1]	DSOCF MIDLH < BIEEF	E W. [0]	O'-MODERATE (1)] O'INTER	MITTENT[-2]	
C<0.2m (P∞i = 0]		,	EK-SLOW [1]			
COMMENTS:		·				
אורה ביפיטא מבפדץ	· E	EFLEIRUN SUBST	PATE	BIEEL EGUN	RIF	FFLE: 4
D - GENERALLY > 10 cm, MAX	GS3 [4] 💢 💢	STABLE (e.g.,Cobt	ale, Soulder) [2]		E [-1] O-MODER	
O · GENERALLY > 10 cm,MAX		MOD. STABLE (e.g		>8 €OW. [1]	D-NONE	
24 GENERALLY 5-10 cm [1]	0.	UNSTABLE (Grave			ſ	ONO RIFFEE(O)
O · GENERALLY « 5 cm (Fill	le - C]	•			·	
OMMENTS	·				GRADIE	NT: 10
Gradient (feet/mile): 15	1.5 Wil	%200L:_		%RIFFLE:	%RUI	N:

UM-2 5/15/00

Rapid Bioassessment Protocol II

Biosurvey Field Data Sheet

RELATIVE ABUNDANCE OF AQUATIC BIOTA

% DO: 194%

Cond: 697 jumbos PH. 8.50

0 = Absent/Not Observed	1 = Rare 2 = Common	3 = Abundant 4 = Dominant
MACROBENTHOS QUALITATIVE	SAMPLE LIST	
Oligochaeta — (List Families Present/Indicate Abundance
		water penny - 1/11
	Anisoptera	Topodo - HT HI (I)
Gastropoda		
***************************************		Coleoptera Dyliscid - 1
Bivalvia	Zygoptera	Elmida - Hunii (12)
Crayfich-1 1		10)
	Plecopiera - LHTLLFT HTT HT	William Kinchied - Hit Harry His
Ephemeroptera Rossia IM 1	1111 (y)	Birdied -1
- SIII	Transit IV	Simulidae-11
	Trichoptera Hel complia-1	-38- [1]
Other	-tor 1 0152 - 11	
RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS		
Scrapers Scrapers	(Indicate No. of Individu	als Representing Group)
Shredders 50	Filtering Collect ING GROUPS (indicate No. of Individuals	Representing Group!
Observations	Total Org. in Sar	nple 5

5/15/00

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Date Issued Date Effective

9-30-89 9-30-89

Figure V-4-6.Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical aphysical characteristics of fish sampling locations. This is used to record additional information about the sampling site and adjacent area.

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Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Oualitative Habitat Evaluation Index (OHEI).

Ohio EPA, Silo D Straim Miller	oscription Shoot - F Creek		ateF	SCORE: 55.5
			CION. END	CWB
TYPE POOL	YTWO Substrate TYPE BOXES; Ch. RIFFLE POOL RIFFL MO-GRAVEL [7] X X	E SUBSTRAT	EQUALITY SUB	STRATE SCORE: [16]
	— BOGWYELIN —			
[6] F3 GJUO 5-C D	C X SAND [6] X XC	-LIMESTONE (1)	RAP [0] CISILT HEA	VY (-2) O-SILT MODERATE (-1
CO-HARDPAN[4]		CHAP	OPAN [O] O - SILT N	ORMAL (0) ES. SILT FREE IT
O O-MUCK (2)		T-244021045 [0]	Extern	Of Embeddness (Check One)
	QQ-ARTIFIC.(0) X	D-SHALE (-1)	0-ex	TENSIVE (-2/0-MODERATE(-
HOTE: Homes styles that one	inates from point-sources; score is ba	JUCAL FINES [-2]		MOI MONE(1)
COMMENTS	mana non pont-socrets, score is as	200 OU UTITLE 200 21515	s)	
				OVER SCORE.
2] INSTREAM COVER	•			OVER SCORE: 6
	E (Check All That Apply)			UNTICHECK ONLY One or
O -UNDERCUT BANKS [1]	12 -0657 POOLS [2]	□ -0x3cws [1]		X 2 and AVERAGE) XTENSIVE > 75% [11]
Z-OVERHANGING VEGETAT	TON(1) D-ROOTWADS(1)			ODERATE 25-75% [7]
SESHALLOWS (IN SLOW WA		COCS OR WOOD	OY DESRIS (1) Or S	PARSE 5.25% (7)
	,,,	74.000	. O - N	EARLY ABSENT < \$1(1)
COMMENTS:				5441 100011 (341)
SINUCSITY DEVE	Check ONLY One PER Category: CHANNEL TANNON	STABILITY M	COLECATIONS OF	
	CELLENT [7] O - NONE [6]		- SNAGGING	a - IMPOUNO.
O MODERATE(3) O GO O LOW(2) 1945 FAI	CO (S) SE- RECOVERED [4]	O - MODERATE (2) O		O-ISLANDS
Q - LOW [2]			- CANOPY REMOVA	
A HOUSE		٥	- DREDGING	O - BANK SHAPING
COMMENTS:	RECOVERY [1]		O - ONE SIDE CRU	ANEL MODIFICATIONS
41 RIPARIAN ZONE AND BAN	X EROSION - (check ONE box per	hank as about 9 and 41	/ED (CE b	RIPARIAN: Q
*River Right Looking Downstream	m'	DAING OF CHECK 2 and A	ENAGE Per Bank)	RIPARIAN: 8
BIPARIAN WICTH	ERCSION/RUNGER - ELOCO PL	APLOUR TY		NK ERCSION
L R (Per Bank)	L R (Most Predominant Per Bu		24	45 23234
0 J' WIDE SOm [4]	OG-FOREST, SWAMP []		NOUSTRIALION YOU	SENONE OR LITTLE [3]
CID'-MODERATE 10-50 (D)	PASTURE ROWCAC			CHICOERATE(Z)
□ □'-NARROW \$-10m [2]	OCH RESID PARK NEW FIELD	II OCHOONSERV T	ILIAGE DI	O-HEAVY OR SEVERE(1)
22 VERY NARROW 1-5m	[1] OO-FENCED PASTURE [1]	O D-MINING/CON		
O30-NONE(0)	.,		01110011011 (0)	
COMMENTS:				
POOLIGIDE AND RIFFLE/RUN	QUALITY			POOL: 14
HAX DESTH (Check 1)	MORPHOLOGY	POY VRUNO	HET E CURHENT Y	ELOCUEY TOTAL
D- > tm (6)	(Check 1)	(Check All T	hat Apply)	
C- 0.7-1m (4)	POOL WIDTH > RIFFLE WIDTH [2]	O'-TOARENTIALL-	1] O'-EODIES[1]	
C- 0.4-0.7m [2] C- F	POOL WIDTH - RIFFLE WIDTH [1]	O'-FAST[1]	O'-INTERSTIT	ML[-1] [THO POOL(0]
2€ < 0.4m[1] □ · ·	POCL WIDTH < RIFFLE W. (0)	0"-MODERATE [1]	D'-INTERMITT	ENT(-2)
C<0.2m (P∞l = 0]		SLOW (1)		
COMMENTS:				
י ארבים ביפון א סבידו				RIFFLE: 5
	EIEFLE/BUN SI		BIEF CAUN EN	
O · GENERALLY > 10 cm, MAX> 5 O · GENERALLY > 10 cm, MAX < 5	V	Cobble, Boulder) [2]		1 O-MODERATE(C)
C. GENERALLY 5-10 cm [1]		E (e.g., Pea Gravei) [1]	C-LOW, [1]	∕ Z€NONEIZ!
D - GENERALLY < 5 cm [Rittle =	O-UNSTABLE (C	oraver,Sand) [C]		[] NO HIFFLE(O)
COMMENTS	- Gj			GRADIENT: 6
] Gradient (feet/mile): 8. //	/ /h			
, o. ao.em (recomme): <u>0. //</u>	Louille xpoo	JC:	%RIFFLE:	

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Rapid Bioassessment Protocol II

Biosurvey Field Data Sheet

MACROBENTHOS QUALITATIVE SAMPLE LIST Digochaeta Ancid I I I I I Families Presentindicate Abundance Water parky - MII Anisoptera Coleoptera Pytical - III B Bivalvia Ephemeroptera Hoptonidae - III III I I I I I I I I I I I I I I		1 2 3	4	Slimes Macroinvertebrates Fish	0 1 0 1 0 1	² 3 ² 3 2 3	4 4 4
Disperse Coleopters Coleopt	0 = Absent/Not Observed	1 = Aare	2 = (Common 3 = Abi	undant	4 = Dominan	t
Disperse Coleopters Dyfreed - Coleopters	MACROBENTHOS QUALITA	TIVE SAMOUS					
Gastropoda Anisoptera Coleoptera Dyficero - [1] (A) Conyclick - [1] (B) Bivalvia Conyclick - [1] (B) Conyclick - [1] (B) Diptera Bro (Ard - [1] (B) Ephemeroptera Hophanidae - [1] (B) Ephemeroptera Hophanidae - [1] (B) Trichoptera Other RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) Scrapers Filtering Collectors CPOM SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) Conservations Conservation	Oligochaeta			List Fa	milies Present/Inc	licate Abundana	
Gastropoda Coleoptera Dyfice Colling Coleoptera Dyfice Colling Bivalvia Coleoptera Coleoptera Dyfice Colling Bivalvia Coleoptera Coleoptera Dyfice Colling Bivalvia Coleoptera				II:00/3	1		
Coleoptera Dyficia - III B Bivalvia Diptera Brocked - III B Coleoptera - Diptera Brocked - III M MM IMM Ephemeroptera Hockedidae - IMM MM IMM Ephemeroptera Hockedidae - IMM MM IMM Bracked - IMM IMM Br				CALL			
Bivalvia Confident Dipters Dipt	Gastropoda						
Bivalvia CELYCA - 1 Plecoptera - 1 Simulidae - IM IM IMM Ephemeroptera Hobesinishe - IMM Trichoptera Other RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS Filtering Collectors Frittering Collectors Foreders Foreders Canada - Sculping indicate No. of Individuals Representing Group) Shredders Canada - Sculping indicate No. of Individuals Representing Group) Total Org. in Sample - IMM Diservations Canada - Sculping in the Suider 17. I mg/L				Coleopte	" Dyliner	-111/4)
Dipters & CARD - MIM IM Ephemeropters Hotenings - MIM MIM Braid - MIM B Trichopters Other RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) Scrapers Filtering Collectors Total Org. in Sample Disservations Canott - Scripes - He Sarder 13.2°C - 17.4 mg/L	Bivatvia	Zygopte	ra .	Chat	111 = 120 m	3)	
Ephemeropiera Hodesindse IIII III IIII IIII IIII IIII IIII II				Diptera 5	3000	11817	
Other RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS Grapers Filtering Collectors COMMANDLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) Scrapers Filtering Collectors Commandation of Individuals Representing Group) Total Org. in Sample Commandation of Individuals Representing Group) Commandation of Individuals Representing Group) Commandation of Individuals Representing Group) Total Org. in Sample Total Org. in Sample Total Org. in Sample	3-16131-1	Piecopte	ra - (1)	5/41/2	THE CARD	MIMI	MIX
RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) SCRIPERS Filtering Collectors Filtering Collectors Total Org. in Sample Congett Scripers Congett Scripers Total Org. in Sample Scripers Congett Total Org. in Sample Total Org. in Sample	Ephemeroptera Hoteainida Bratia - IM 11 (8)		100	eld r	ed - 111	THOU IN	111
RIFFLE SAMPLE FUNCTIONAL FEEDING GROUPS Groups Filtering Collectors Filtering Collectors Filtering Collectors Total Org. in Sample Caught Formation Scripps Total Org. in Sample Scripps Filtering Collectors Formation Formation Total Org. in Sample Scripps Filtering Collectors Filtering Collectors Formation Formation Total Org. in Sample Filtering Collectors Formation Form	Other						
FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) Scrapers Filtering Collectors CPOM SAMPLE FUNCTIONAL FEEDING GROUPS (Indicate No. of Individuals Representing Group) Total Org. in Sample Caucht Scripes + 46 Sample Total Org. in Sample							
Filtering Collectors	UNCTIONAL FEEDING GROUP	PS .	(Indicate No	of lading			*
introducts in the sample 54 Deservations Caught Sculping in the sample 54 Caught Sculping in the sample 54							- 1
caught as Sculpins in the surber Them = 13.2 °C 17.4 mg/L	POM SAMPLE FUNCTIONAL	FEEDING GROUPS	(indicate No. of	Ing Collectors			
conget on scripins in the surber temp = 13.2°C = 17.4 mg/L	nreaders (-		Total (Org. in Samula (17)	(P)		
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temp=13.2°C	¥		~: TEN)	4			
= 17,4 mg/L							
= 17,4 mg/L	-1 17-						- 1
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Cond = 781 jumhos pH = 8.33 Procedure No. Revision No.

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Date Issued Date Effective 9-30-89 9-30-89 UM-3 5/16/00

Figure V-4-6.Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record additional information about the sampling site and adjacent area.

Additional Commers	-	n Impedia								_	
				-						_	
a	EAR	DISTANC	;	WATER	CLARITY		NATER S	TAGE			
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THERO PASS	_ :		 						BLBLECTI		AESTHE
	95		GRADE	NT:)9-Ú	ow 6-MOD	ERATE	Ô-HIGH		(1-19) PHOTOS:	us	/1-10t
TREAM MEASUR	EMENT:	: AVERA	GE WIDT	nt:	O AVE	PAGE D	₽TH:	5′			
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Procedure No. Revision No. WOPA-SWS-1

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Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Oualitative Habitat Evaluation Index (OHEI).

Ohlo EPA Silo Doce Street Harshman	ription Shoot - Fic	RMOate	3,4, 0004
	C. L TYPE BOYES &	_ c	im DB/CWP
CO-BOULDER (9) CO-COBBLE (8) CO-HARDPAN (4) CO-MUCK (2) TOTAL NUMBER OF SUBSTRATE NOTE: (Ignore studge that originales	DE POOL RIFFLE **CO-GRAVEL [7]	SUBSTRATE (SUBSTR	RUALITY SUBSTRATE SCORE: 4 III) SIR CONT (Check One) P(0) O-SILT HEAVY (-2) O-SILT MCDERATE (-1) AN [0] AS SILT NORMAL [0] O-SILT FREE [11] ELECT OF EMBRIDGES (Check One) O-EXTENSIVE (-2) O-MODERATE (-1) JOHNONE [1] O-NONE [1]
COMMENTS			
2) INSTREAM COVER 17-PE (Ch. O-UNDERCUT BANKS [1] 25-COVERMANGING VEGETATION [1] 25-SHALLOWS (IN SLOW WATER) COMMENTS:		O OX3CWS [1] O AQUATIC MICROP Q COGS OR WOODY	COVER SCORE: US AMOUNTCHES ONLY One of check 2 and AVERAGE O - EXTENSIVE > 75% [11] WYTES (1)-OS MODERATE 25-75% [7] DEBRIS [11] O - SPARSE 5-2% [2] DEBRIS [11] O - SPARSE 5-2% [2]
3] CHANNEL MORPHOLOGY: (CM. SIMUOSITY DEVELOPM O- HIGH (4) O- EXCELL TO MODERATE (3) D4 GOOD [5 O- LOW (2) O- FAIR (3) O- NONE (1) O- POOR (1) COMMENTS:	ENT CHANNEL TATION S ENT [7] O NONE [6] O RECOVERED [4] O RECOVERED [4] O RECOVERING [7]	TABILITY MCO HIGH [D] D - S MODERATE [2] D - R LOW [1] D - C	IFICATIONS/OTHER NAGGING DIMPOUND.
			
4) RIPARIAN ZONE AND BANK ERG "River Right Locking Downstream" RIPARIAN WIDTH	OSION - (check ONE box per ba		RAGE per bank) RIPARIAN: S
0 0 - WIDE SAM [4] 0 0 0 - WODESATE 10-S3 [3] 2 2 0 - WARROW S-10m [2] 0 0 - WARROW 1-Sm [1] 0 0 0 - WODE[0]	R (Most Predominant Per Bank O-FOREST, SWAMP [1] X-OPEN PASTURE! ROWCROP[O-RESIDLPARK, NEW FIELD [1] O-FENCED PASTURE [1]	ONI RO MABRUCIO CLO RO EURHRICIO (O	FIELD(Z) D TEMODERATE(Z) AGE (1) ST OHEAVY OR SEVERE(1)
COMMENTS:			
D-0.4-0.7m [2]	MORPHOLOGY (Check 1) WIDTH > RIFFLE WIDTH [2] WIDTH - RIFFLE WIDTH [1] WIDTH < RIFFLE W. [0]	POTABLIMATE (Check All That O'TORRENTIAL(-1) O'TAST[1] O'MODERATE [1] ESTSLOW [1]	POOL: q
COMMENTS:			
RETLEMUN DEPTH - GENERALLY > 10 cm, MAX > 50 [4] - GENERALLY > 10 cm, MAX < 50 [3] - GENERALLY > 10 cm, MIX < 50 [3] - GENERALLY < 5 cm [7] - GENERALLY < 5 cm [7] - OMMENTS	PIEZI E RIVN SUB: OSTABLE (a.g.,CC O-MOO, STABLE (O-UNSTABLE (Gra	oble, Soutcer) [2] (RIFFLE: 4 DETERMINE EMBEDOPONESS DETERMINE [-1] DIMOGRATE(0) DIMONESS DEMONESS DIMONESS DIMO
Gradient (teet/mile): 8 4/m:	%P00L:		RIFFLE: %RUN:

Rapid Bioassessment Protocol II

Biosurvey Field Data Sheet

Periphyton 0 1 Filamentous Algae 0 1 Macrophytes 0 1	2 3 4 Slimes 3 4 Macroinvi 2 3 4 Fish	ertebrates 0 1 2 3 4 0 1 (2) 3 4
0 = Absent/Not Observed	= Rare 2 = Common	3 = Abundant 4 = Dominant
MACROBENTHOS QUALITATIVE SAME	I E LIOT	
Oligochaeta	water peras-HTIII (2)	List Families Present/Indicate Abundance
Gastropoda	Anisoptera	
Bivalvia — ())) (i))	Zygoptera	Coleopters Districted - 1 D
Cre Carl	Piecopiera - Att HTHM HT	Diplera P. MANAHTHAM III (29
Ephemeroptera Leptroco da - HM 110	(39	
cana-11	richoptera	
Other HFFLE SAMPLE UNCTIONAL FEEDING GROUPS	Linechildae (2)	
Grapers GROUPS	(Indicate No. of Individuals Re	presenting Group)
POM SAMPLE FUNCTIONAL FEEDING (Filtering Collectors	
predders	Total Org. in Sample	5 ©

xter temp = 14.0°C DO = 14.8 mg/L %DO = 147% pt = 8.21 Cor d = 686 junhos Procedure No. Revision No. WOPA_SWS-3

Date Issued
Date Effective

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Figure V-4-6.Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical in physical characteristics of fish sampling locations. This is used to record additional information at the sampling site and adjacent area.

	is Reach Repres Additional Comm			/AQ	I Not				
			Š						
	FIRST PASS	GEAR	DISTAN	 :	WATER CL	ARITY	WATER STA	<u> </u>	
	BECOND PASS THEPD PASS							SUBJECTIVE RATING	AESTHETIC RATING
	STREAM MEASI		3: 050		•	Ô-MODERATE		124 (- US / 14-E
	LENGTH WIDTH	H DEP	THSD		M:	AVERAGE	DEPTH:		N_SUPERUN
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								土土土	
				CR	OSS-SECTI	ONS OF STREAM			
(, c,)	(0.1)							•	
Dist fin LB Dep (4)	(filser) Velock		_]		•				
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17.0 18.0 19.0 RWE		-			_				

OA Manual (6th Update) - Fish - September 30, 1989

Procedure No. WOPA-SWS-3
Revision No. 6

Date Issued Date Effective 9-30-89 9-30-89 UM-5 5/16/00

Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Oualitative Habitat Evaluation Index (OHEI).

Stream Soi don Creek	on Shoot - Fish	RM0*		Code
1) SUBSTRATE (Check ONLYTwo Substr	NA TYPE BOYES: Check -		CION. ESIS/CU	ν <u>P</u>
TYPE POOL RIFFLE	POOL RIFFLE	Sincini;	AULUM CURCTO	
		PARTITION	QUALITY SUBSTR	A I E SCORE: DI
CO-BCDEN (SCAS) (10) ECOCA	AVEL [7] 🗶 🔀 Substit	ata Ottalii (cyecx	all) Sin Cover (heck One!
	NO (6) X XO-LIMES	TONE [1 DERIPA	LP [O] OF SILT HEAVY [-	2] C-SILT MODERATE [-1]
OO-COBBLE(5) ×× DO-BE		√[1] ;Æ¥HARD	PAN [0] AS SILT NORM	AL [0] O-SILTERETIN
O-HAROPAN[4] O-0E	TRITUS(1)C-SANC	2 I CUE [0]	Extent Of Ea	nbeddness (Check One)
0.0-MUCK [2] 0.0-AR	TIFIC.[0] 🔀OSHAL	.E (-1)	O-EXTENS	NE[-2]C-MODERATE[-1]
TOTAL NUMBER OF SUBSTRATE TYPES:		. FINES [-2]	رowio	O-NONE[1]
NOTE: (Ignore studge that onginates from poi	int-sources; score is based on	(אוניבו מרסבעונאב)		•••
COMMENTS				
•			COV	ER SCORE: 9
2] INSTREAM COVER	•	,	AMOUNTO	Check ONLY One or
TYPE (Check All T				AVERAGE
O -UNDERCUT BANKS [1]	>5.0 [2] D. POOLS (2)	OXBOWS [1]		SIVE > 75% [11]
			PHYTES (1) C . MODE	DATE 26.75× CT
DE SHALLOWS (IN SLOW WATER) [1]		OGS OR WOODS	DEBRIS [1] OF SPARS	5 5.35 / /31
	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		O MEAD	Y ABSENT < 5%[1]
COMMENTS:	••	•		1 400541 5 32(1)
3] CHANNEL MORPHOLOGY: (Check ONL	Y One PER Category OR cha	er 2 and AVE240	:n	CHANNEL: 105
SINUOSITY DEVELOPMENT	CHANNELIZATION STAB		DIECATIONS/OTHER	CHAMILE. [154]
O . HIGH [4] O . EXCELLENT [7]				IMPOUND.
	O RECOVERED [4] DE MO			
	D RECOVERING (DI)D LO	0000015[2] 0-		ISLANDS
	O . RECENT OR NO		ANOPY REMOVAL O	
a - none (i)				BANK SHAPING
COMMENTS:	RECOVERY [1]	4	D - ONE SIDE CHANNE	L MODIFICATIONS
4] RIPARIAN ZONE AND BANK EROSION - "River Right Looking Downstream"	(check ONE box per bank or	check 2 and AVE	RAGE per bank)	RIPARIAN: 8
RIPARIAN WIGTH EROSION				
EECSION	FUNCES - FLOCO PLAIN OL	IAI TV	BANK F	ROSION
	(SUNGEE - FLOOD PLAIN CL.		BANK E	BOSION
LR (Per Bank) LR (Mos	it Predominant Per Bank) L	R (Per Bank)	. 1	•
L R (Per Bank) L R (Mos	t Predominant Per Bank) L ST, SWAMP [3]	R (Per Bank) C-URBAN OR IN	DUSTRIALIOI BY DANC	NE OR LITTLE [3]
L R (Per Bank) DD WIDE-Som [4] DD MCDERATE 10-50 [3] CD 0PEN	It Predominant Per Bank) L ST, SWAMP (D) C I PASTURE/ ROWCROP(O) C	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL	DINELENTO DE LO MO	NE OR LITTLE (3) DERATE(2)
L R (Per Bank) D.T. WIDE-Som [4] D.T. MODERATE 10-50 [3] D.T. MODERATE 10-50 [3] D.T. MARROW 5-10m [2] D.D. RESI	It Predominant Per Bank) L EST, SWAMP [0] D I PASTURE/ ROWCROP[0] D O.,PARK,NEW FIELD [1] D	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL C-CONSERV. TIL	DUSTRIALIO DE CANO DIFIELO(S) DI GANO LAGE (1) DI GANE	NE OR LITTLE [3]
L R (Per Bank) C D WIDE-Som [4] C D-FORE C D MODERATE 10-50 [0] C D-RESII C D-RESII C D-RESII C D-RESII C D-RESII	It Predominant Per Bank) L EST, SWAMP [0] D I PASTURE/ ROWCROP[0] D O.,PARK,NEW FIELD [1] D	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL	DUSTRIALIO DE CANO DIFIELO(S) DI GANO LAGE (1) DI GANE	NE OR LITTLE (3) DERATE(2)
R (Per Bank)	It Predominant Per Bank) L EST, SWAMP [0] D I PASTURE/ ROWCROP[0] D O.,PARK,NEW FIELD [1] D	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL C-CONSERV. TIL	DUSTRIALIO DE CANO DIFIELO(S) DI GANO LAGE (1) DI GANE	NE OR LITTLE (3) DERATE(2)
L R (Per Bank) D : WIDE-Som [4] D : WIDE-Som [4] D : OD-FORE D : WIDE-Som [4] D : OD-FENC D : VERY MARROW 1-Sm [1] D : VERY MARROW 1-Sm [1] COMMENTS:	It Predominant Per Bank) L EST, SWAMP [0] D I PASTURE/ ROWCROP[0] D O.,PARK,NEW FIELD [1] D	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL C-CONSERV. TIL	DUSTRIALIO DE CANO CARLO (2) CO-MO CARLO (3) CO-HE	DINE OR LITTLE [3] COERATE[3] AVY OR SEVERE[1]
L R (Per Bank) C D'-WIDE-Som [4] C D'-WOES-RATE 10-50 [2] C D'-NORE[0] C D'-NORE[0] C D'-NORE[0] COMMENTS: POOUGLIDE AND RIFFLE/RUN CUALITY	IL Predominant Per Bank) L ST, SWAMP [0] O PASTUREY ROWCRCP[0] C O.,PARK,NEW FIELD [1] O ED PASTURE [1] O	R (Per Bank) CURBAN OR IN CUSHRUB OR OL COCONSERV. TIL CUMINING/CONS	DUSTRIALIO) BY DANC DIFIELDIZI DI DANC LAGE (1) DI DANE PRUCTION (0)	POOL: 7
L R (Per Bank) L R (Mos D WIDE Son L R (Mos D CO-MOSE ST 10-50 D CO-PS D CO-MAROW 5-10n R D CO-PS D CO-MAROW 1-5m R D C-PS C D CO-MONE D CO-MS C D CO-MONE D CO-MS C D C C D C C C C C C C C C C C C C C C	II Predominant Per Bank) L ISST, SWAMP [0] I PAASTURE ROWGROP[0] C D.PARK,NEW FIELD [1] C ED PASTURE [1] C	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL C-CONSERV. TIL C-MINING/CONS	DUSTRULLO DE DANC DIRECTO (2) DO MC LAGE (1) DO ME IRUCTION (0)	POOL: 7
L R (Per Bank) C D'-WIDE-Som [4] C D'-WIDE-Som [4] C D'-WOES-ATTE 10-50 [2] C D'-COPEN C D'-WARROW S-10m [2]	II Predominant Per Bank) L ISST, SWAMP [3] I PASTUREY ROWCRCP[6] OPARK, NEW FIELD [1] ED PASTURE [1] UND COCY tak 1)	R (Per Bank) ID-URBAN OR IN ID-URBAN OR IN ID-CONSERV. TIL ID-MINING/CONS POST-PUNING/CONS (Check All Tha	DUSTRIAL(O) BY DANC DIRECTOR DIRECTOR OFF TRUCTION (O) THE CUBHENT VEI ON 14 APP(Y)	POOL: 7
L R (Per Bank) C D'-WIDES Son [4] C D'-MOES Son [4] C D'-MOES Son [6] C D'-MOES STATE 10-SO [3] C D'-MOES STATE 10-SO [3] C D'-MOES MARROW 1-SM [1] C D'-RONE[0] C DM-MENTS: POOU/GUIDE AND RIFFLE/RUN QUALITY MAX 055TH [Check 1] C D-1m[6] C 0.7-Im[6] C D-POOU WIDTH	II Predominant Per Bank) [I STS SWAMP [2] 0 0 0 0 0 0 0 0 0	R (Per Bank) C-URBAN OR IN C-SHRUB OR CL C-CONSERV. TIL C-MINING/CONS	DUSTRIAL(O) BY DANC DIRECTOR DIRECTOR OFF TRUCTION (O) THE CUBHENT VEI ON 14 APP(Y)	POOL: 7
R (Per Bank)	II Predominant Per Bank) L SST, SWAMP [3] O I PASTUREY ROWGROP[9] O O.,PARK, NEW FIELD [1] O ED PASTURE [1] O I POSTURE [1] O I POSTURE [1] O POSTURE [1] O - RIFFLE WIOTH [2] O - RIFFLE WIOTH [1] O	R (Per Bank) CURBAN OR IN O-SHRUB OR CL O-CONSERV. TIL O-MINING/CONS POT- /PLIN/PII (Check A// Tha -TORRENTIAL(-1) -FAST[1]	DUSTRIAL(O) BY DANC DIRECTOR DIRECTOR OFF TRUCTION (O) THE CUBHENT VEI ON 14 APP(Y)	POOL: 7
L R (Per Bank) C D'-WIDE-Som [4] C D'-WIDE-Som [4] C D'-WOES-ATTE 10-50 [2] C D'-OPEN C D'-NARROW S-10m [2] C D'-NARROW S-10m [2] C D'-NARROW S-10m [2] C D'-NARROW S-10m [2] C D'-WOES NARROW S-10m [2] C D'-STM [4] C D'-POCC WIDTH C C 4-0.7m [2] C POCC WIDTH C C C VIDTH	II Predominant Per Bank) L SST, SWAMP [3] O I PASTUREY ROWGROP[9] O O.,PARK, NEW FIELD [1] O ED PASTURE [1] O I POSTURE [1] O I POSTURE [1] O POSTURE [1] O - RIFFLE WIOTH [2] O - RIFFLE WIOTH [1] O	R (Per Bank) CURBAN OR IN O-SHRUB OR CL O-CONSERV. TIL O-MINING/CONS POT- /PLIN/PII (Check A// Tha -TORRENTIAL(-1) -FAST[1]	DUSTRIALIO DE CAMO DI RELO[2] DI OLME LAGE [1] DI OLME RIUCTION (0] THE CUPHENT VELO 1 Apply) DI EDDIES[1]	POOL: 7
R (Per Bank)	II Predominant Per Bank) L SIST, SWAMP [3]	R (Per Bank) CURSAN OR IN CSHRUS OR OL CSONSERV. TIL CMINING CONS POST PRIMARIE (Check All Thu TORRENTIAL(-1) FAST[1] MODERATE [1]	DUSTRIALIO D'ANC D'AELOZI D'AME LAGE (1) D'AME IRUCTION (0) THE CURHENT VELOX I APPIY) D'ADDESTI	POOL: 7
L R (Per Bank) C D'-WIDE-Som [4] C D'-WIDE-Som [4] C D'-WOES-ATTE 10-50 [2] C D'-OPEN C D'-NARROW S-10m [2] C D'-NARROW S-10m [2] C D'-NARROW S-10m [2] C D'-NARROW S-10m [2] C D'-WOES NARROW S-10m [2] C D'-STM [4] C D'-POCC WIDTH C C 4-0.7m [2] C POCC WIDTH C C C VIDTH	II Predominant Per Bank) L SIST, SWAMP [3]	R (Per Bank) CURBAN OR IN O-SHRUB OR CL O-CONSERV. TIL O-MINING/CONS POT- /PLIN/PII (Check A// Tha -TORRENTIAL(-1) -FAST[1]	DUSTRIALIO D'ANC D'AELOZI D'AME LAGE (1) D'AME IRUCTION (0) THE CURHENT VELOX I APPIY) D'ADDESTI	POOL: 7
R (Per Bank)	II Predominant Per Bank) L SIST, SWAMP [3]	R (Per Bank) CURSAN OR IN CSHRUS OR OL CSCONSERV. TIL CMINING CONS POST PRIMAGE (Check All Thu TORRENTIAL(-1) FAST[1] MODERATE (1)	DUSTRIALIO D'ANC D'AELOZI D'AME LAGE (1) D'AME IRUCTION (0) THE CURHENT VELOX I APPIY) D'ADDESTI	POOL: 7
R (Per Bank)	IL Predominant Per Bank) L STS, SWAMP [0]	R (Per Bank) O SHAND OR IN O SHAND OR CO COONSERV. TIL O MININGCONS POOL / PUNMAN (CHECK AITTH -FAST[1] -MODERATE [1] SLOW [1]	DUSTRIALIO D'ANC D'AELOZI D'AME LAGE (1) D'AME IRUCTION (0) THE CURHENT VELOX I APPIY) D'ADDESTI	NE OR LITTLE [3] DEFATE,[3] ANY OR SEVERE[1] POOL: 7 IN OR POOL: 7 RIFFLE: 6
L R (Per Bank) L R (Mos OD:WIDE-Som [4] OD-FORE OD:WIDE-Som [4] OD-FORE OD:WARROW S-10m [2] OD-RESI OD:WARROW S-10m [2] OD-RESI OD:WARROW S-10m [2] OD-RESI OD:WARROW S-10m [2] COMMENTS: POOUGLIDE AND RIFFLE/RUN QUALITY MAX 05211 [Check 1] O->1m [6] O->1m [6] O->1m [6] O-0.4-0.7m [2] O-0.4-0.7m [2	II Predominant Per Bank) L SIST, SWAMP [3]	R (Per Bank) CURSAN OR IN OSHANS OR OR OSHANS OR OR OSHANS OR OR OSHANS OR POST PUNETUR (COMMAND OR OSHANS (DUSTRIALION OF CANCE OF RELOGICAL OF CANCE (1) OF CANCE (POOL: 7
R (Per Bank)	II Predominant Per Bank) L SST, SWAMP [0] O PASTURE FOWGROUP[0] O D.PARK, NEW FIELD [1] O D.PARK, NEW FIELD [1] O D.PASTURE [1	R (Per Bank) CURSAN OR IN OSHRUS OR CIC OSCONSERV, TIL OMINING CONS 2001/FUNYETT (Check All Tha TORRENTIAL(-1) FAST[1] MODERATE (1) SLOW (1) TE Souther) [2]	DUSTRIALION OF CAME DIRECTION OF COMME TRUCTION O	POOL: 7
R (Per Bank)	IL Predominant Per Bank) L STS, SWAMP [0] C PASTUREY ROWGROPIQ CO.,PARK, NEW FIELD [1] C C.,PARK, NEW FIELD [1] C C.,PARK	R (Per Bank) OURSAN OR IN OUSHAUS OR CI OCONSERV. TIL OMININGCONS POT- PUMPRIT TORRENTAL(-1) FAST(1) MODERATE (1) SLOW (1) TE BOURM) (2) PAS Grave) (1)	DUSTRIALION OF CANCEL DI RELORI DI RELORI DI CHE RICCHION (O) TRE CURRENT VELO TAPPIY) DI REDERSTITAL(-1 DINTERMITTENTI RICCHION EMBRON DEXTENSIVE (-1) COEXTENSIVE (-1) COEXTENSIVE (-1) COEXTENSIVE (-1)	POOL: 7
R (Per Bank)	II Predominant Per Bank) L SST, SWAMP [0] O PASTURE FOWGROUP[0] O D.PARK, NEW FIELD [1] O D.PARK, NEW FIELD [1] O D.PASTURE [1	R (Per Bank) OURSAN OR IN OUSHAUS OR CI OCONSERV. TIL OMININGCONS POT- PUMPRIT TORRENTAL(-1) FAST(1) MODERATE (1) SLOW (1) TE BOURM) (2) PAS Grave) (1)	DUSTRIALION OF CAME DIRECTION OF COMME TRUCTION O	POOL: 7 IN E OR LITTLE [3] DEFATE,[2] AVY OR SEVERE[1] POOL: 7 IN POOL: 7 RIFFLE: 6 MODERATE(9)
R (Per Bank)	IL Predominant Per Bank) L STS, SWAMP [0] C PASTUREY ROWGROPIQ CO.,PARK, NEW FIELD [1] C C.,PARK, NEW FIELD [1] C C.,PARK	R (Per Bank) OURSAN OR IN OUSHAUS OR CI OCONSERV. TIL OMININGCONS POT- PUMPRIT TORRENTAL(-1) FAST(1) MODERATE (1) SLOW (1) TE BOURM) (2) PAS Grave) (1)	DUSTRIMUO D'ONC D'ELD(2) D'OME LAGE (1) D'OME RRUCTION (0) THE CURHENT VELON 1 APPLY) D'INTERSTITIAL (-1 D'INTERSTITIAL	POOL: 7 PIFFLE: 6 PONESS RIFFLE: 6 PONESS CONTROL C
L R (Per Bank)	IL Predominant Per Bank) L STS, SWAMP [0] C PASTUREY ROWGROPIQ CO.,PARK, NEW FIELD [1] C C.,PARK, NEW FIELD [1] C C.,PARK	R (Per Bank) OURSAN OR IN OUSHAUS OR CI OCONSERV. TIL OMININGCONS POT- PUMPRIT TORRENTAL(-1) FAST(1) MODERATE (1) SLOW (1) TE BOURM) (2) PAS Grave) (1)	DUSTRIMUO D'ONC D'ELD(2) D'OME LAGE (1) D'OME RRUCTION (0) THE CURHENT VELON 1 APPLY) D'INTERSTITIAL (-1 D'INTERSTITIAL	POOL: 7
L R (Per Bank)	II Predominant Per Bank) L STS, SWAMP [0] O IPASTURE FOWGROP[0] O IPASTURE [1] O	R (Per Bank) CURRAN OR IN OSHAUS OR CIC OSHA	DUSTRIALION OF CANCE OF RELOGIZE OF CHECK OF CANCE (1) O	POOL: 7 IN POOL:
L R (Per Bank) L R (Mos DD - WIDES Som [4] DD - FORE DD - WARROW S - I om [2] DD - WARROW S - I om [4] DD - D - I om [4] DD - D - I om [4] DD - D - I om [4] DD - WARROW S - I om MAX - SD [4] DD - GENERALLY - I O om MAX - SD [4] DD - GENERALLY - I O om MAX - SD [4] DD - GENERALLY - I O om MAX - SD [4] DD - GENERALLY - I O om MAX - SD [4] DD - GENERALLY - I O om MAX - SD [4] DD - GENERALLY - I O om MAX - SD [4] DD - GENERALLY - I O om [7] DD - GENERALY - I OM [IL Predominant Per Bank) L STS, SWAMP [0] C PASTUREY ROWGROPIQ CO.,PARK, NEW FIELD [1] C C.,PARK, NEW FIELD [1] C C.,PARK	R (Per Bank) CURRAN OR IN OSHAUS OR CIC OSHA	DUSTRIMUO D'ONC D'ELD(2) D'OME LAGE (1) D'OME RRUCTION (0) THE CURHENT VELON 1 APPLY) D'INTERSTITIAL (-1 D'INTERSTITIAL	POOL: 7 PIFFLE: 6 PONESS RIFFLE: 6 PONESS CONTROL C
L R (Per Bank)	II Predominant Per Bank) L STS, SWAMP [0] O IPASTURE FOWGROP[0] O IPASTURE [1] O	R (Per Bank) CURRAN OR IN OSHAUS OR CIC OSHA	DUSTRIALION OF CANCE OF RELOGIZE OF CHECK OF CANCE (1) O	POOL: 7 IN POOL:

Rapid Bioassessment Protocol II

Biosurvey Field Data Sheet

RELATIVE ABUNDANCE OF AQU Periphyton 0 1 Filamentous Algae 0 1 Macrophytes 0 1	2 3 4 2 3 4	Slimes Macroin Fish	vertebrates	0.	1 1 1	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	3 3 3	4 4 4
and Conserved	1 = Rare	2 = Common	3 = Abu	ndant		4-	Domin	ent
MACROBENTHOS QUALITATIVE SA	MPLFIIST							
Oligochaeta - HT LHT 17 17			List Fac	nilles Pre	sent/l	ndicate A	Abundan	_
	2			الان		141/4	#12	747711
	Anisoptera							2000
Gastropoda RHS-1	-							-
Ramshorn - 1 10	1		Coleopter	D.J	عرف	id-4	H 449	an und
	Zygoptera		Dryn.	الأبدأة	- //	110)	an initia
Bivalvia -/ ()	1		<u> </u>					-
	Piecoptera -	1	Diptera	10.00	írá ·	147.	UsT I	(3)
		-		See	- 41	TUT!	mem	mmmith.
phemeroptera								- 1
	Trichoptera							- 1
her								
FFLE SAMPLE								
NCTIONAL FEEDING GROUPS	Unc	Icate No 1 .						, l
apers		icate No. of Individuals Re	presenting Gr	oup)				
OM SAMPLE FUNCTIONAL FEEDING	GROUPS "	Filtering Collectors						- 1
edders 2	(indici	ite No. of Individuals Repn	esenting Group	D)				
ervations		Total Org. in Sample	50		_			1
								- 1
								- 1

unter temp= 14,200 DO = 2006 mg/m 800 = 2008 Cond = 2007 mg/m PH = 8,69 Procedure No. Revision No.

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Fm LB

WOPA_SWS_3

Date Issued Date Effective 9-30-89 9-30-89 5/16/00

Figure V-4-6.Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record additional information about the sampling site and adjacent area.

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is Search Servi		Street (1/80	×					
Additional Con								_
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FIRST PASS	GEAR	DISTANC	WATER	CLARITY	WATER ST	44 F		
						— LJ		
ECOND PASS						SUBJECTA	E AESTHETIC	
THERD PASS	_				<u>, </u>	RATING	RATING	
ANOPY (NOPE	a)		RADIENT: Ó-LO	W O-MODERA	ITE Ö-HIGH	(1-19)	E - 101-101	. A-
						· //	3-15/12	~~~(Car
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DRAWING OF STREAM

UM-6 5/15/00

OA Manual (6th Update) - Fish - September 30, 1989

Procedure No. Revision No. WOPA-SWS-3

Date Issued Date Effective

9-30-89 9-30-89

Figure V-4-5. Front side of the Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of lish sampling locations. This is used to record information for the calculation of the Oualitative Habitat Evaluation Index (OHEI).

Onio EPA Silo Doscrip Stem Goshen Cree		h RMOate	QHEI SCO	
Location UM-C		C/e	MEDB/CWB	
☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐	POOL RIFFLE GRAVEL[7] SAND [6] SAND [6] SEDROCK(S] SECONOCK(S)	SUBSTRATE QU.	0) C-SILT HEAVY [-2] C	EX One
O D-MUCK [2] TOTAL NUMBER OF SUBSTRATE TYPE NOTE: (Ignove studge that anginates from COMMENTS	S: 2 4 [2] 2 4 [0] 0-C	HALE (-1) CAL FINES (-2) on natural substrates)	O-rowld O-extensive	[-2]O-MODERATE[-1]
2] INSTREAM COVER TYPE (Check A O -UNDERCUT BANKS [1] 820VERHANGING VEGETATION [1]	OEEP POOLS [2]	D -0x3cws [1]	AMOUNT(Che check 2 and a D - EXTENSIV	E > 75% [11]
SHALLOWS (IN SLOW WATER) [1]	Q BOULDERS [1]	PROUNTIC MACROPH PROOS OR WOODY DE	TES (1) DO MODERAT BRIS (1) O - SPARSE S A NEARLY A	-25% [3]
COMMENTS:			<u> </u>	
I] CHANNEL MORPHOLOGY: (Check of SINUOSITY DEVELOPMENT OF HIGH [4] OF EXCELLENT	CHANNELIZATION ST	ABILITY MCOIE	CATIONS/OTHER	HANNEL: 35
X: MODERATE (3) XC GOOD (5)				POUND.
O · LOW [2] · O · FAIR [3]	RECOVERED [4]	MODERATE (Z) OF REL		ANDS -
D . NONE [1] D . POOR [1]	RECOVERING [3] O -		OPY REMOVAL O - LE	
COMMENTS:	RECOVERY[1]	Q - DRE	ONE SIDE CHANNEL M	NK SHAPING ODIFICATIONS
41 8184 814 W 70NE 4 ND 8 4 N EROSIO	N /25 005			DARIAN.
4] RIPARIAN ZONE AND BANK EROSIO "River Right Looking Downstream"	M - (cueck ONE pox bet bet	A OF CHECK I AND AVERA	GE per bank) III.	PARIAN: 9
	ONRUNOFE - FLOCO PLAIN			
	Host Predominant Per Bank)		BANK ERC	211214
	DREST, SWAMP (3)	CO-URBAN OR INDUS	TRUM TO MONE	001 000 5 131
	PEN PASTURE/ ROWCROPIC			OR LITTLE [3]
	ESID., PARK, NEW FIELD [1]	DO-CONSERV. TILLAC		Y OR SEVERE[1]
DO -VERY MARROW 1-Sm [1] DO-FE		D-MINING CONSTRU		on sevencery
COMMENTS:				
POOLIGLIDE AND RIFFLE/RUN QUALITY				POOL: 7
MAX DEPTH (Check 1) MC	RPHOLOGY	POYTH /OHIN/AIRTH	E CURHENT VELOCIT	
	heck 1)	(Check All That A		-
	TH > RIFFLE WIDTH [2]		O'-EDDIES(1)	
	TH - RIFFLE WIOTH [1]		O'INTERSTITIAL[-1]	D NO POOLO
	TH < RIFFLE W. [0]		O'INTERMITTENTI-21	
C<0.2m (P∞I = 0]		SCSTOM 1:1		
COMMENTS:	· · · · · · · · · · · · · · · · · · ·			
BIEST ENSUN DESTRA	BIEFLE-BUN SUBS	***************************************	FFLEMUN EMBEDDES	RIFFLE: 3
O - GENERALLY > 10 cm, MAX-50 [4]	D-STABLE (e.g.,Cot		EXTENSIVE I-11 O-MC	
C - GENERALLY > 10 cm,MAX & 50 [3]	D-MOD. STABLE (LOW. [1]	
SA GENERALLY 5-10 cm [1]	MUNSTABLE (Grav			O-MO RIFFEE(O)
D - GENERALLY < 5 cm (Rittle = 0)				
COMMENTS			GRA	DIENT: 6
6] Gradient (feet/mile):	%POOL:_	%RI	FFLE: %	RUN:

UM-6 5/15/00

Rapid Bioassessment Protocol II

Biosurvey Field Data Sheet

RELATIVE ABUNDANCE OF AC Periphyton 0 1 Filamentous Algae 0 1 Macrophytes 0 1	2 3 4 2 3 4 2 3 4	macroin	vertebrates 0 1 2 3 4
0 = Absent/Not Observed	1 = Rare	Fish 2 = Common	0 2 3 4
MACROBENTHOS QUALITATIVE	SAMPLE LIST		
Oligochaeta	T		List Families Present/Indicate Abundance
			Isapela - 11(2)
	Anisoptera		
Gastropoda Physides - III /			
Planorbidge (Heliana) -11	(3)		Coleoptera Beetle ? (Melysiche 1)
Phosph //	Zygoptera		Dryspide THE THE THE THE ME IT
Bivalvia TH TH TH TH TH +	91-		Dytisidae-1 1)
(991年末年年 (991年年		KICHT THE YHA	Diptera
Ephemeroptera	///	(2)	Brann Chiconomidiae HHUMA)
<u>C</u> ,			
Canylor-111 3	Trichoptera		
Other			Hazziters - Bootman
IFFLE SAMPLE			
UNCTIONAL FEEDING GROUPS	line	IICALE No. of tour	
crapers		licate No. of Individuals R	
POM SAMPLE FUNCTIONAL FEEDI	NG GROUPS	Filtering Collectors	
redders 2	Tiodr's (indica	ite No. of Individuals Rep	resenting Group)
servations		Total Org. in Sample	50
Sample uo	is jarred		

water temp = 15.7°C DO = 23.7mg/L %DO = 239% Cord = 709 unhos PH = 8.08

UM-6 5/15/6

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Date Issued Date Effective

9-30-89

Figure V-4-6.Reverse side of the Ohio EPA Site Description Sheet for evaluating the geographical aphysical characteristics of fish sampling locations. This is used to record additional information about the sampling site and adjacent area.

	FRST PASS	FRST PASS		DISTAN	c	WATER CL	ARITY	WATER S	TAGE	П	
	BECOND PAS THERD PASS	_	 ·						a	BJECTME RATING	AESTHETI RATING
	CANOPY (%C	 	45		GRADE	MI SELOW	Ó-MODERAT	E Ó-HIGH		71-1Q	1-45//C
	STREAM MI	EASUR	EMENT	S: AVER	GE WIDT	H: 15	AVERAGE	DEPTH:_	۱a′′		PTH_30
- ;;}		MOTH		THIS D							COLGLD-RIFR
!!		50,7	300	10"	5"						P004
		12'	16.1	12"	8"	-		+	+		POOL
		10'	٦′′	4"	≇"						RIF
	120/13	20/	8"	12"	20"			-		\Box	P002
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1.0 .5	03	3				PRAWING (OF STREAM				
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PHOTOGRAPH PLATES



HARZA

Sears Tower Fax: (312) 831-3999

Page 1

233 South Wacker Drive

Telephone: (312) 831-3000

Chicago, Illinois 60606-6392 U.S.A.

Telex: 25-3540 HARZENG CGO

WATERSHED DIAGNOSTIC ANALYSIS

Project No.: 16749

190

Project: Upper Mississinewa River, Randolph Co., Indiana

INSPECTION PHOTOS



DIRECTION. E

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Upstream view of upper reach of sample site UM1 on Mud Creek, just south of Hwy 28.



DATE: 5/15/00

TIME: pm

DIRECTION: W

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Downstream view of lower reach of sample site UM1 on Mud Creek, just south of Hwy 28.







Sears Tower Fax: (312) 831-3999 233 South Wacker Drive

Telephone: (312) 831-3000

Chicago, Illinois 60606-6392 U.S.A.

Telex: 25-3540 HARZENG CGO

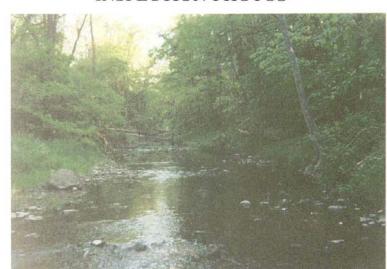
WATERSHED DIAGNOSTIC ANALYSIS

age 2

Project No.: 16749

Project: Upper Mississinewa River, Randolph Co., Indiana

INSPECTION PHOTOS



DATE: 5/15/00

TIME: pm

DIRECTION: S

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Upstream view of upper reach of sample site UM2 on Clear Creek, just south of Hwy 28.

DATE: 5/15/00

TIME: pm

DIRECTION: N

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Downstream view of lower reach of sample site UM2 on Clear Creek, just south of Hwy 28.





Sears Tower Fax: (312) 831-3999 233 South Wacker Drive

Telephone: (312) 831-3000

Chicago, Illinois 60606-6392 U.S.A.

Telex: 25-3540 HARZENG CGO

WATERSHED DIAGNOSTIC ANALYSIS

Project No.: 16749

Page 3

Project: Upper Mississinewa River, Randolph Co., Indiana

INSPECTION PHOTOS



TIME: am

DIRECTION: S

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Upstream view of upper reach of sample site UM3 on Miller Creek, just south of CR 750 N, in channelized section of creek.



DATE: 5/16/00

TIME: am

DIRECTION: N

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Downstream view of lower reach of sample site UM3 on Miller Creek, just south of CR 750 N in channelized section of creek.





HARZA

Sears Tower Fax: (312) 831-3999 233 South Wacker Drive

Telephone: (312) 831-3000

Chicago, Illinois 60606-6392 U.S.A.

Telex: 25-3540 HARZENG CGO

WATERSHED DIAGNOSTIC ANALYSIS

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Project No.: 16749

Project: Upper Mississinewa River, Randolph Co., Indiana

INSPECTION PHOTOS

DATE: 5/16/00

TIME: am

DIRECTION: S

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Upstream view of upper reach of sample site UM4 on Harshman Creek, just south of CR 800 N.



DATE: 5/16/00

TIME: am

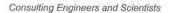
DIRECTION: N

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Downstream view of lower reach of sample site UM4 on Harshman Creek, just south of CR 800 N.





HARZA

Sears Tower Fax: (312) 831-3999 233 South Wacker Drive

Telephone: (312) 831-3000

Chicago, Illinois 60606-6392 U.S.A.

Telex: 25-3540 HARZENG CGO

WATERSHED DIAGNOSTIC ANALYSIS

Project No.: 16749

Page 5

Project: Upper Mississinewa River, Randolph Co., Indiana

INSPECTION PHOTOS



TIME: pm

DIRECTION: N

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Upstream view of upper reach of sample site UM5 on Jordon Creek, just north of CR 950 N.



DATE: 5/16/00

TIME: pm

DIRECTION: S

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Downstream view of lower reach of sample site UM5 on Jordon Creek, just north of CR 950 N.





Consulting Engineers and Scientists

233 South Wacker Drive

Telephone: (312) 831-3000

Chicago, Illinois 60606-6392 U.S.A.

Telex: 25-3540 HARZENG CGO

WATERSHED DIAGNOSTIC ANALYSIS

Project No.: 16749

Page 6

Sears Tower Fax: (312) 831-3999

Project: Upper Mississinewa River, Randolph Co., Indiana

INSPECTION PHOTOS



TIME: am

DIRECTION: N

PHOTOGRAPH TAKEN BY: EJB/CWB

COMMENTS:

Upstream view of upper reach of sample site UM6 on Goshen Creek, just north of CR 900 N.



DATE: 5/16/00

TIME: am

DIRECTION: S

PHOTOGRAPH

TAKEN BY: EJB/CWB

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COMMENTS:

Downstream view of lower reach of sample site UM6 on Goshen Creek, just north of CR 900 N.



AGRICULTURAL BEST MANAGEMENT PRACTICES

APPENDIX E AGRICULTURAL BEST MANAGEMENT PRACTICES (BMPS)

Best management practices, or BMPs, are restrictions, structures or practices that mitigate the adverse anthropogenic effects on runoff quality and/or quantity. Agricultural BMPs include various types of conservation buffers such as grassed waterways, no-till cropping, and many other structures and practices. The relative effectiveness of the BMP for reducing storm runoff peaks and volumes, and for addressing pollutants are generalized in the matrix below. Each BMP is subsequently described in more detail.

Table E-1

GENERAL EFFECTIVENESS OF SELECT AGRICULTURAL BMPS

ВМР	Suspended Solids	Nitrogen	Phosphorus	Runoff Volume
Impoundments				
Dry Detention Ponds	•	•	•	•••
Wet Detention Ponds	•••	••	••	•••
WASCOBs				
Wetland Basins	•••	••	•••	•••
Wetland Channels	••	••	••	••
Vegetative Filters		-	·	
Filter Strips	••	•	•	•
Grassed Waterways	••	•	•	•
Farm Management Practic	es			
Residue Management	•••	••	••	••
Stripcropping	•••	••	••	••
Terracing	•••	••	•••	•••
Nutrient Management	••	•••	•••	••
Others				
Sand Filtration	•••	•	••	•

^{• =} Usually not very effective treatment

^{••• =} Usually very effective treatment

1. SAND FILTERS

Sand filters are a type of stormwater control structure used to treat runoff from buildings, roads, parking lots. Sand filters are also used to treat potable water, industrial process water and agricultural wastewater. Sand filters may be installed underground in trenches or pre-cast concrete boxes or above-ground in beds that can treat stormwater from drainage areas as much as five acres in size.

Sand filters are most common in urban areas and on sites with restricted space. The City of Austin, Texas and the State of Florida have built large, above-ground sand filters. Underground sand filters have been installed in several eastern states. Both versions pretreatment to remove sediment, floating debris, and oil and grease to protect the filter. As stormwater flows through the filter bed, sediment particles and adsorbed pollutants are captured.

Pollutant removal for sand filters varies depending on the site, climate and loading. Overall removal for sediment and trace metals is better than removal of soluble pollutants. Table E-2 lists removal rates taken from the literature. Unfortunately, due to the large areas requiring treatment in agricultural crop watersheds, sand filters are generally not utilized.

Table E-2

SAND FILTER RELATIVE POLLUTANT REMOVAL EFFICIENCY

(Source: Schueler, et al. 1992)

Pollutant	Efficiency	
Bacteria	Moderate	
Oil and Grease	High	
BOD	Moderate	
Trace metals (sediment-bound)	Very High	
Sediment	Very High	
Total Phosphorus	Moderate	
Total Nitrogen	Moderate	

2. BUFFERS, FILTER STRIPS AND GRASSED WATERWAYS

Vegetation reduces the velocity of stormwater. This improves infiltration and sedimentation, as well as prevents erosion. Vegetation is often part of a BMP system to remove particulates and slow runoff before it enters another treatment device. Buffer stips, filter strips and grassed waterways are described in this section.

The NRCS defines a filter strip as a strip or area of herbaceous vegetation situated between cropland, grazing land, or disturbed land (including forest land) and environmentally sensitive areas. NRCS defines a buffer strip similarly, as a strip or strips of perennial vegetation established in crop fields for wildlife habitat, erosion control, and water quality. Both of these BMPs generally apply in areas situated below cropland, grazing land, or disturbed land where sediment and/or contaminants may leave these areas and are entering environmentally sensitive areas. The NRCS' definition of a grassed waterway is a natural or constructed channel shaped or graded and established in suitable vegetation for the stable conveyance of runoff.

None of these BMPs are part of the adjacent cropland rotation. Overland flow entering filter strips or buffer strips shall be primarily sheet flow. Concentrated flow is dispersed by grading so that the flow is overland, as sheet flow.

Filter strips are typically areas of close-growing vegetation between pollutant sources and receiving waters. They can be used as outlet or pretreatment devices for other stormwater control practices. Filter strips can include shrubs or woody plants that help to stabilize herbaceous and grassy ground cover, or can be composed entirely of trees and other natural vegetation. Filter strips generally do not significantly reduce peak discharges or the volume of storm runoff, but they can be part of a comprehensive BMP system for meeting these needs.

According the NRCS standards, the filter strip should be located along the downslope edge of a field. The average watershed slope above the filter strip should be greater than 0.5% but less than 10%. The average annual sheet and rill erosion rate above the filter strip should be less than 10 tons per acre per year.

Strips should not be less than 20 feet, and protection of some resources may require much wider vegetation strips. Upgradient land slopes greater than 6% should have wider strips,

possibly as wide as 130 feet. Floodplain buffer strips having higher flows and longer duration flooding may need to be upwards of 200-feet wide.

Although studies indicate highly varying pollutant removal, trees in strips can be more effective than grass strips alone because of the trees' greater uptake and long-term retention of plant nutrients. Properly constructed forested and grassed filter strips can be expected to remove more than 60 percent of the particulates and perhaps as much as 40 percent of the plant nutrients in urban runoff. Filter strips function best when they are level in the direction of stormwater flow toward the stream. This orientation makes for the finest sheetflow through the strip, increasing infiltration and filtering of sediment and other solids. Filter strips fail if maintenance is irregular.

Grassed swales are waterways vegetated with a dense growth of a hardy grass such as tall fescue or reed canary grass. A grassed waterway/vegetated filter system is a natural or constructed vegetated channel that is shaped and graded to carry surface water at a nonerosive velocity to a stable outlet that spreads the flow of water before it enters a vegetated filter. Grassed waterways and swales are common in agricultural and urban settings.

Minimum capacity for design of grassed waterways is generally intended to confine the peak runoff from a 24-hour, 10-year storm. Waterways may provide some reduction in stormwater pollution through infiltration of runoff water into the soil, filtering of sediment or other solid particles, and slowing the velocity and peak flow rates of runoff. These processes can be enhanced by adding small (4-10 inches high) dams across the swale bottom, thereby increasing detention time.

Pollutants are removed from surface flow by the filtering action of the grass, sediment deposition, and/or infiltration into the soil. The pollutant-removing effectiveness of swales is moderate to negligible depending on many factors, including the quantity of flow, the slope of the swale, the density and height of the grass cover, and the permeability of the underlying soil. Pollutant removal ranges from 30 to 90 percent for sediment and 0 to 40 percent for total phosphorus loads (Table E-3).

Table E-3

VEGETATIVE PRACTICES POLLUTANT REMOVAL EFFICIENCY

(Source: Schueler, 1987, Schueler et al. 1992)

Pollutant	Efficiency
Bacteria	Low
Oil and Grease	Moderate
BOD	Low
Trace metals	Moderate
Sediment	Moderate
Total Phosphorus	Low
Total Nitrogen	Low

To be effective, vegetative practices require flat areas that are large in relation to the drainage area, and deep water tables. Swales should have as little slope as possible to maximize infiltration and reduce velocities. Filter strips should not be used where slopes exceed 15 percent, and best performance occurs where the slope is 5% or less. Taller grass will slow velocities more but grass cut to a short length may take up more plant nutrients.

3. CONSTRUCTED WETLANDS

Over the last two decades, interest has increased for the use of natural physical, biological, and chemical aquatic processes for the treatment of polluted waters. Aquatic treatment systems have been divided into natural wetlands, constructed wetlands, and aquatic plant systems (USEPA, 1988). Of the three types, constructed wetlands have received the greatest attention for treatment of nonpoint source pollution. Constructed wetlands are a subset of created wetlands designed and developed specifically for water treatment (Fields, 1993). Constructed wetlands may be developed strictly for mitigation of adverse effects from development on natural wetlands. But, in this context, constructed wetlands serve in a similar capacity as other water quality BMPs, that is, to minimize pollution prior to its entry into streams, lakes and other receiving waters.

Among the most important treatment processes are the purely physical processes of sedimentation, induced by reduced velocities in the wetland. Sedimentation accounts for the relatively high removal rates for suspended solids, the particulate fraction of organic matter and sediment-bound nutrients and metals. Oils and greases are effectively removed through impoundment, photodegradation, and microbial action. Similarly, pathogens show good removal rates in constructed wetlands via sedimentation, natural die-off, and UV degradation. Dissolved constituents such as soluble organic matter, ammonia and ortho-phosphorus tend to have lower removal rates. Soluble organic matter is largely degraded aerobically by bacteria and periphyton. Ammonia is removed through microbial nitrification-denitrification, plant uptake, and volatilization. Nitrate is removed through denitrification and plant uptake. Denitrification is the primary removal mechanism. The microbial degradation processes are relatively slow, particularly the anaerobic denitrification steps, and require longer residence times, a factor which contributes to the variable performance of constructed wetlands systems for dissolved nitrogen. Phosphorus is removed mainly through soil sorption, plant assimilation and burial, processes which are slow and varied. Consequently, phosphorus removal rates are variable and typically trail behind those of nitrogen.

Constructed wetlands can achieve or exceed the pollutant removal rates as estimated for wet pond detention basins and dry detention ponds. General ranges of removal for various pollutants are given below.

Table E-4

CONSTRUCTED WETLAND POLLUTANT

REMOVAL EFFICIENCY (Source: Schueler, 1987, Schueler *et al.* 1992)

Pollutant	Efficiency
Bacteria	High
Oil and Grease	Very high
BOD	Moderate
Trace metals (sediment-bound)	High
Sediment	High
Total Phosphorus	High
Total Nitrogen	Moderate

The use of constructed wetlands for stormwater treatment remains an emerging technology and design criteria continue to evolve. General design considerations include the requirement to reduce stormwater inflow velocities and provide opportunity for initial

sedimentation. It is important to maximize the hydraulic residence time and the distribution of flow over the treatment area, and to avoid hydraulic short-circuiting. Emergent macrophytes provide substrate for periphyton and are a storage vector for carbon and nutrients. Generally, native emergent vegetation is designed for. Plants must be chosen to withstand the pollutant loading and the frequent fluctuation in water depth.

Constructed wetlands can be a very effective part of a BMP system. Associated features should incorporate minimization of initial runoff volumes; routing of runoff using grassed waterways, swale checks, and other measures; pre-treatment of collected runoff to minimize sediment and associated pollutant loads; and, off-line attenuation of larger storm event runoff to optimize wetland performance and minimize downstream erosion-related water quality impacts.

4. NATURAL AND RESTORED WETLANDS

Natural wetlands also improve water quality. Protection or restoration of wetlands to maintain or enhance water quality is acceptable. However, nonpoint source pollutants should not be intentionally diverted to wetlands for primary treatment. Wetlands should be part of an integrated landscape approach to nonpoint source control, and tied to BMPs in upgradient source areas.

5. WET RETENTION PONDS

Wet retention ponds or basins temporarily detain stormwater. The permanent pool of water enhances the removal of many pollutants. These ponds fill with stormwater and release it slowly. Pollutant removal mechanisms in wet ponds include: sedimentation; biological uptake by plants, algae and bacteria; and, decomposition. Wet ponds have some capacity to remove dissolved nutrients, an important characteristic to protect lakes from eutrophication. Because of the permanent pool, wet ponds can remove moderate to high amounts of most pollutants and are more effective in removing nutrients than most other BMPs.

E-7

Table E-5

WET DETENTION POND POLLUTANT REMOVAL EFFICIENCY

(Source: WEF & ASCE, 1998)

Pollutant	Wet Retention Pond	Extended Detention Pond	
BOD	20 – 40%	20 – 40%	
Zinc	40 – 50%	40 – 50%	
Lead	70 – 80%	70 – 80%	
Sediment	70 – 80%	70 – 80%	
Dissolved Phosphorus	50 – 70%	0	
Total Phosphorus	50 – 60%	20 – 50%	
Dissolved Nitrogen	50 – 70%	0	
Total Nitrogen	30 – 40%	20 – 30%	

6. WATER AND SEDIMENT CONTROL BASIN (WASCOB)

Water and sediment control basins, or WASCOBs, are earth embankments or combinations of ridges and channels, generally constructed across the slope and minor watercourses to form a sediment trap and a water detention basin. WASCOBs are a popular BMP, and hundreds have been constructed in Indiana alone. These structures improve the ability to farm sloping land, reduce watercourse and gully erosion, trap sediment, reduce and manage onsite and downstream runoff, and improve downstream water quality.

This practice applies to sites where:

- 1. The topography is generally irregular,
- 2. Waterway and/or gully erosion is a problem,
- 3. Sheet and rill erosion is controlled by other conservation practices,
- 4. Runoff and sediment has damaged land and improvements,
- 5. Soil and site conditions are suitable, and,
- 6. Adequate outlets are available or can be provided.

This practice is not applicable to waterways where construction of the basin would destroy important woody wildlife cover and the present watercourse is capable of handling the concentrated runoff without serious erosion.

Water and sediment control basins are consistent with terrace intervals (see Table E-9). The drainage of each basin is designed to limit the duration of ponding, infiltration, or seepage so that the structure does not damage nearby crops. Where land ownership or physical conditions preclude treatment of the upper portion of a slope with terraces, a water and sediment control basin may be used to separate this area from, and permit treatment to the lower part of the slope. The uncontrolled drainage area to the basin used for this purpose should not exceed 30 acres.

The basins should be large enough to control the runoff from a 10-year, 24-hour-frequency storm without overtopping. The capacity of basins designed to provide flood protection or to function with other structures may be larger. Another storage volume design consideration is the anticipated accumulation of sediment, which could be estimated with the Universal Soil Loss Equation (USLE).

WASCOBs should be part of an overall system to protect soil and water resources. Practices such as terracing, contouring, conservation cropping, conservation tillage, and crop residue management should also be used to control erosion.

Water and sediment control basins shall not be used in place of terraces. When a ridge and channel extend beyond the detention basin or level embankment, terraces are appropriate.

This BMP may reduce the volume and rate of discharge. When underground outlets are used, infiltration through the catchment will increase and runoff will be decreased. Peak flows will be reduced by temporary storage. Where snow is present, it is trapped in the channels and catchments of the BMP and infiltrates into the soil. This BMP traps and removes sediment-attached pollutants from runoff. Trap efficiencies for sediment and total phosphorus may exceed 90 percent in Indiana's silt loam soils. Dissolved substances, such as nitrates, may also be removed from discharge from downstream areas with increased infiltration.

7. RESIDUE MANAGEMENT

There are several agricultural BMPs that increase the plant residue in soils and reduce erosion. Among these are no-till/strip till, mulch till, ridge till, and seasonal residue

management. Each of these BMPs is instrumental in conserving soil moisture, increasing soil infiltration, reducing soil loss, and improving soil tilth.

The NRCS defines no-till/strip till as managing the amount, orientation and distribution of crop and other plant residues on the soil surface year round, while growing crops in narrow slots, or tilled or residue free strips in soil previously untilled by full-width inversion implements. This practice applies to all cropland and other land where crops are grown. Combines or similar machines used for harvesting are equipped with spreaders that distribute plant residue over the fields so that residues are retained on the field. Post-harvest grazing should not be allowed. Planters are equipped to plant directly through untilled residue or in a tilled seedbed prepared in a narrow strip along each row. Although not universal, no-till planting generally relies on an increased use of herbicides to control weeks, but greatly reduces soil loss from the fields. No till or strip till can be practiced continuously or may be part of a system which includes other tillage and planting methods such as mulch till.

The mulch till practice is similar, and defined by NRCS as managing the amount of crop and other plant residues on the soil surface year round while growing crops where the field surface is tilled prior to planting. This BMP applies to all crop land and applies to tillage for both annual and perennial crops. Tillage implements are equipped to operate through plant residues without clogging and to maintain residue on or near the soil surface by undercutting or mixing. Planters, drills, or air seeders plant in residue on the soil surface or mixed in the tillage layer.

Ridge till is manages the amount of crop residues on the soil surface year-round, while growing crops on preformed ridges alternated with furrows protected by crop residue. Following harvest, residues are left until planting with no additional disturbance except for normal weathering. Ridge height is maintained throughout the harvest and winter seasons by controlling equipment or livestock traffic. After planting, residues are maintained in the furrows until the ridges are rebuilt by cultivation. Ridges are rebuilt to their original height and shape during the last row cultivation. Loose plant residues are retained on the field and uniformly distributed on the soil surface. Cultivation and planting equipment designed to operate on ridges is used, such as cultivators equipped with ridging attachments, and planters equipped with ridge planting attachments such as row cleaning devices and guidance systems. Planting and fertilizer placement shall disturb no more than one third of the row width. Soil and residue removed from the top of

the ridge shall be moved into the furrow between the ridges. After planting, the top of the ridge is at least three inches higher than the furrow between the ridges.

Seasonal residue management involves using plant residues to protect cultivated fields during critical erosion periods. Wherever possible, the farmer should leave stubble standing over winter to prevent soil erosion and to trap snow. The management of crop residue is based on the amount of residue produced by the crop. When relatively small amounts of residues are available other practices will have to be used to maintain the necessary residue cover. This may include limiting grazing of the crop residues and not baling the cover.

8. STRIPCROPPING

Contour stripcropping is the growing of crops in a systematic arrangement of strips or bands on the hillside contour to reduce water erosion. The crops are arranged so that a filter strip of grass or close-growing crop is alternated with a strip of clean-tilled crop or fallow; or a strip of grass is alternated with a close-growing crop. Contour stripcropping is applicable to sloping cropland and on certain recreation and wildlife land where the topography is uniform enough to permit tilling and harvesting, and where it is an



essential part of a cropping system to effectively reduce soil and water losses.

Contour strips should outlet into a stable outlet such as a waterway, water and sediment control basin, field border or other nonerosive areas and not outlet into end rows where excessive erosion down the slope might be accelerated. Contour strips are established with consideration given to

the field and machinery conditions with up to 10 percent deviation of strip widths permissible (Table E-6).

Table E-6

CONTOUR STRIP WIDTHS
(Source: NRCS Conservation Standards)

Slope P Values ¹⁷		Maximum Strip Width ^{2/}	Maximum Slope Length ^{3/}		
(%)	Α	В	С	(feet)	(feet)
1 to 2	0.30	0.45	0.60	130	800
3 to 5	0.25	0.38	0.50	100	600
6 to 8	0.25	0.38	0.50	100	400
9 to 12	0.30	0.45	0.60	80	240
13 to 16	0.35	0.52	0.70	80	160

1/ P Values:

- A For 4-year rotation of row crop, small grain with meadow seeding, and 2 years of meadow.
- B For 4-year rotation of 2 years row crop, winter small grain with meadow seeding, and 1-year meadow.
- C For alternate strips of row crop and winter small grain.
- 2/ Adjust strip width limit, generally downward, to accommodate widths of farm equipment.
- 3/ Maximum length may be increased by 10 percent if residue cover after crop planting will regularly exceed 50 percent.

Field stripcropping is similar to contour stripcropping. Field stripcropping is the growing of crops in a systematic arrangement of strips or bands across the general slope, not on the contour, to reduce water erosion. The crops are arranged so that a strip of grass or close-growing crop is alternated with a clean-tilled crop or fallow. It is applicable for controlling erosion and runoff on sloping cropland where contour stripcropping is not practical. Strips are laid out across the slope as nearly on the contour as practicable. No two adjoining strips will be in clean-tilled crops or fallow. As with contour stripcropping, grassed waterways, water and sediment control structures, terraces or diversions should be established and maintained where concentrated water flow would otherwise cause gully erosion. The widths of strips are defined below. A deviation of 20% in width is acceptable.

Table E-7

FIELD STRIPCROPPING STRIP WIDTHS
(Source: NRCS Conservation Standards)

Percent Slope	Strip Width (feet)		
1 – 2	130		
3 – 8	100		
9-16	80		

Both field and contour stripcropping affect the water budget, especially volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation and ground water recharge. These BMPs also have filtering effects on water quality because the strip vegetation and reduces movement of sediment and dissolved and sediment-attached substances

9. TERRACING

A terrace is an earth embankment, channel, or a combination ridge and channel constructed across the slope to reduces slope length, erosion, and sediment content in runoff water. It is a broadly practiced BMP wherever water erosion is a problem, there is a need to conserve water, and the soils and topography are such that terraces can be reasonably constructed and farmed.

As with stripcropping, terrace spacing is usually determined by the Universal Soil Loss Equation (USLE). The spacing shall not exceed the slope length determined by using the allowable soil loss, the most intensive use planned, the expected level of management, and the terrace P factor (Table E-8).

Table E-8

TERRACE P FACTORS (Source: NRCS Conservation Standards)

Horizontal Interval	Closed Outlets ¹	Open outlets, with percent grade		rcent grade 2
(feet)		0.1-0.3	>0.3-0.7	>0.7
<110	0.5	0.6	0.7	1.0
110 - <140	0.6	0.7	0.8	1.0
140 - <180	0.7	0.8	0.9	1.0
180 - <225	0.8	0.8	0.9	1.0
225 - 300	0.9	0.9	1.0	1.0
>300	1.0	1.0	1.0	1.0

NOTES:

If contouring or stripcropping P factors are appropriate, they can be multiplied by the terrace P factor for the composite P factor.

The maximum horizontal interval between terraces should not exceed the distances tabulated below for the conditions shown.

^{11 &}quot;P" factor for closed outlet terraces also apply to terraces with underground outlets and to level terraces with open outlets.

^{2/} The channel grade is measured on the 300 ft of terrace or the one-third of total terrace length closest to the outlet, whichever is less.

Table E-9

MAXIMUM HORIZONTAL INTERVAL FOR TERRACES
(Source: NRCS Conservation Standards)

Slope	USLE – F	Factors	With Contour Stripcropping
	35 to 175	>175	
(%)	(ft)	(ft)	(ft)
0-2	500	450	600
2.1 – 4	400	300	600
4.1 – 6	400	200	600
6.1 – 9	300	150	400
9.1 – 12	250	150	250
12.1 – 18	200	150	150
18.1 – up	200	150	150
Minimum spacing required, all slopes	150	90	90

The maximum limits should not be exceeded when making adjustments as indicated below. Spacing may be increased as much as 10% to provide better alignment or location, to adjust for farm machinery, or to reach a satisfactory outlet. Spacing may be increased an additional 10% for terraces with underground outlets. For level terraces used for erosion control and water conservation, the spacing is determined as indicated above, but the maximum horizontal spacing should never exceed 600 ft. Additionally the terrace shall have enough capacity to control the runoff from a 10-year frequency, 24-hour storm without overtopping. Other design criteria are available from the NRCS.

Terraces should be part of the treatment system to protect soil and water resources. In addition, practices such as contouring, a conservation cropping system, conservation tillage, and crop residue management shall also be used to control erosion. Terraces should not be used in place of water and sediment control basins. The planned management system should reduce soil loss in the terrace interval to prevent excess maintenance and operation problems.

Storage terraces retain runoff, increase infiltration, and conserve soil moisture. Gradient terraces may cause a slight increase to a significant decrease in surface runoff depending on field topography and terrace channel grade. This BMP reduces slope length and the

amount of surface runoff which passes over the area downslope from the structure. The erosion rate and production of sediment within the terrace interval will be reduced. Terraces trap sediment and reduce the sediment and associated pollutant content in the runoff water.

Terraces intercept and conduct surface runoff at a nonerosive velocity to stable outlets, thereby reducing gully erosion. Trap efficiencies for sediment and total phosphorusmay exceed 90 percent for terraces with underground outlets in Indiana's silt loam soils. Underground outlets may collect soluble nutrient and pesticide leachates and convey them directly to surface waters. In this way, by collecting surface runoff and conveying it directly to a receiving stream, terraces may increase the delivery of pollutants to surface waters. Terraces may have a detrimental effect on water quality if they concentrate and accelerate delivery of dissolved or suspended nutrient or pesticide pollutants to surface or ground waters.

10. NUTRIENT MANAGEMENT

Proper nutrient management economizes the natural process of nutrient cycling to optimize crop growth and minimize environmental losses. According to NRCS (1999), the practice of nutrient management serves four major functions:

- 1. Supplies essential nutrients to plants for adequate production,
- 2. Provides for efficient and effective use of scarce nutrient resources.
- Minimizes environmental degradation caused by excess nutrients in the environment, and,
- Helps maintain or improve the physical, chemical, and biological condition of the soil.

Modern agricultural production depends on an adequate supply of nutrients being available to the crops. The agricultural yield increases during the last 50 years can be, in part, attributed to high levels of crop nutrition that support high yielding crop varieties. Unfortunately increased use of nutrients has, and continues to, damage the environment. Excess nutrients produce nuisance vegetation including algae, which diminish the economic, social and environmental benefits of aquatic and terrestrial habitats.

The objective of nutrient management is to supply adequate chemical elements to the soil and plants without creating an imbalance in the ecosystem. Protecting the environment

requires controlling both the source of nutrients and their fate and transport from those sources. Nutrient management assessment tools available include tools to assess the agronomic needs of a crop and tools to assess environmental risk associated with nutrient applications. Agronomic needs assessment tools include:

- Traditional soil tests, providing an important baseline of information, should be performed every 3 to 5 years, or more often if conditions change.
- Plant tests provide information on the nutrient status of the crop, and can determine the success of the current nutrient management plan in meeting crop needs.
- Organic materials analysis, where manure or municipal sewage sludge are applied to fields, should include moisture content. These data are necessary to develop an accurate nutrient budget.

Environmental risk assessment tools provide information on the fate, transport and potential environmental risk associated with nutrient applications. These tools may identify sensitive areas where nutrient management is critical to protect a water resource. A few of the less complex risk assessment tools include:

- The leaching index (LI) assesses the intrinsic probability of leaching occurring if nutrients are present and available to leach. LI is a simple index of potential leaching based on average annual percolation and seasonal rainfall distribution.
- The Universal Soil Loss Equation (USLE) assesses the potential for soil and adsorbed nutrient loss through water erosion.
- The Water Quality Indicators Guide (WQIG) is a qualitative tool for assessing surface water quality impacts from five major sources of agriculturally related nonpoint source pollution: sediment, nutrients, animal waste, pesticides, and salts.
- The Nitrate Leaching and Economic Analysis Package (NLEAP) is a moderately complex, field scale model that assesses the potential for nitrate leaching under agricultural fields. NLEAP can be a powerful tool to assess nutrient management planning decisions.
- The phosphorus index (PI) is a simple assessment tool that examines the potential risk
 of P movement to streams and lakes based on various landforms and management
 practices.
- The 303(d) list can often be used to help assess the potential environmental risk associated with a particular land area. Indiana's 303(d) report is available at www.
 This report lists waterbodies designated as impaired for one or more of its designated uses.

- Water quality monitoring can be used to assess the potential impairment of
 waterbodies and associated environmental risk. Long-term monitoring, such as
 monitoring performed by the IDEM and U.S. Geological Survey can show
 quantitative trends in water quality over time.
- A variety of water quality models, including AGNPS, WATERSHED, ANAGNPS, SWRRB, and SWAT, may be used to look at the influence of different management scenarios and environmental conditions on the potential environmental risk of nutrient contamination to waterbodies.

A nutrient management plan is a farm's guide for making decisions on the placement, rate, timing, form, and method of nutrient application. They help producers become fully aware of the steps that need to be taken to successfully manage their nutrients and protect natural resources. Components of a nutrient management plan are listed in the adjacent text box. These elements are all-inclusive, but are guidelines for the minimum requirements for a nutrient management plan.

There are abundant references on nutrient conservation practices for pollution control and reduction. Many of the available techniques are related to soil erosion control. Nutrient control techniques generally fall into one or more of the following categories:

- Source reduction
- Reduction of nutrient availability
- Reduction of soil particle detachment
- Reduction of dissolved and suspended nutrient transport

Nutrient Management Plan Components

- 1. Aerial photographs or maps
- 2. Sensitive resource areas and nutrient restriction areas
- Results of soil, plant and organic materials analyses
- 4. Crop sequence and rotation plan
- 5. Expected crop yields
- Quantification of nutrient sources
- 7. Crop nutrient budget
- 8. Recommended rates, timing and methods

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